Ambix

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THE LATE DR. E. J. HOLMYARD

It is with deep sorrow that we have to record the death at Clevedon, Somerset, on 13 October, 1959, of the Society's former Chairman,—Dr. Eric John Holmyard.

An Obituary will be published in the next issue of *Ambix*.

AN EARLY MEDIAEVAL CHINESE ALCHEMICAL TEXT ON AQUEOUS SOLUTIONS*

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I. Introduction

It is often supposed that Chinese alchemists busied themselves mostly with non-aqueous reactions of a more or less metallurgical character. The text we now present throws a considerable light on the earliest beginnings of the chemistry of inorganic reactions in aqueous medium. Weak nitric acid was employed to bring into solution a large number of inorganic substances, the processes being carried out either in porcelain vessels or in lengths of bamboo tubing which acted in part as a semi-permeable membrane. The text also includes mention of certain curious phenomena which were probably the effects

* Except for the name of Dr. Ts'ao at the head of this paper, the romanisation of Chinese names and words used herein (as in the previous paper by Ho & Needham) follows that modification of the standard Wade-Giles system in which the aspirate sign is replaced by the letter *h* (see further Needham (21), vol. 1, pp. 23 ff.).

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of enzymes from organic material. It thus shows that the making of gold for the preparation of the elixir of immortality was far from being the only interest of these early mediaeval experimentalists. At the same time mica and certain other minerals were long regarded in China as among the substances from which potent elixirs might be made[a], and this no doubt explains the motive of the alchemists in their efforts to bring various mineral substances into solution. The title of our text is *San-shih-liu Shui Fa*[1] (Thirty-Six Methods for the Bringing of Solids into Aqueous Solutions). The first thing to do is to try to date it.

II. Date of the Text

Aqueous solutions of mineral substances were known to Chinese alchemists at least as early as the time of Ko Hung[3] (c. +280 to +360), who in his *Pao Phu Tzu*[2] gives an account of the preparation of aqueous solutions of realgar and cinnabar, mentioning an earlier work called the *San-shih-liu Shui Ching*[4] (Manual of the Thirty-Six [Methods for] the Bringing of Solids into Aqueous Solution).[b] Elsewhere he knows how ". . . to turn the thirty-six minerals directly into aqueous solutions"[c]. Another alchemical treatise, entitled *Huang-Ti Chiu Ting Shen Tan Ching Chüeh*[5] (Explanation of the Yellow Emperor's Manual of the Nine-Vessel Magical Elixir)[d], mentions a *San-shih-liu Shui Fa*[1] saying that Pa Kung[6] imparted these techniques to the well-known—2nd-century alchemist Liu An[7], Prince of Huai-nan[8e]. It adds that "the solubilization of alum (*fan-shih*[9]), realgar (*hsiung-huang*[10]) and cinnabar (*tan-sha*[11]) is all based on Pa Kung's manual of the thirty-six methods for bringing solids into solution. The methods all depend on the use of nitre (*hsiao-shih*[12]). In the case of the solubilization of cinnabar, copper sulphate (*shih-tan*[13]) is needed." The *Yün Chi Chhi Chhien*[14] (The Seven Tablets of the Cloudy Satchel) ca. + 1025, on the other hand, also attributes a book with a similar name to Thao Hung-Ching[15] (+452 to + 536) the great physician and alchemist of the Liang period.[f] The title is rather revealing, namely *Fu Yün-Mu Chu Shih Yao Hsiao Hua San-shih-liu Shui Fa*[16] (Thirty-Six Methods for the Bringing of Substances into Aqueous Solution [by means of] Transformations caused by Nitre [with a view to the] Ingestion of Mica and all Kinds of Mineral Drugs). It was in one chapter, just as our text still is.

[a] *Cf.* Feifel (12), p. 15, translating *Pao Phu Tzu*[2], Nei Phien, ch. 11, pp. 9*b* ff.

[b] *Pao Phu Tzu*, Nei Phien, ch. 16, pp. 9*a*, *b*, 10*a*, *b* and ch. 19, p. 4*b*.

[c] *Pao Phu Tzu*, Nei Phien, ch. 3, p. 1*b*. Feifel (10), p. 182, translates, most inadequately, ". . . to change the thirty-six stones suddenly into water."

[d] Date Thang or Sung, but incorporating some material as old as the +2nd century.

[e] Ch. 8, pp. 1*a*, 2*a* and 4*a*.

[f] *Yün Chi Chhi Chhien* (W/1020), ch. 107, p. 9*a*.

The book we are studying comes from the *Tao Tsang*[17] (Taoist Patrology)[g] but does not reveal the name of its author. It is true that it quotes a saying of an alchemist named Kao Chhi[18], but unfortunately we know nothing about him or his date. Our book is almost certainly the same as that listed in the bibliographical chapter of the *Sung Shih*[19] (History of the Sung Dynasty), +1345, and also identical with the work known to the compiler of the *Thung Chih*[20] (+1150) by the name *Lien San-shih-liu Shui Shih Fa*[21]. The book was thus well known by the Northern Sung (+11th century), but the authorship remains obscure. As we shall see, comparison with other alchemical texts strongly indicates that some at least of the methods described must have been known in the time of Ko Hung[3] (+3rd and +4th centuries). The text now contains more than 36 recipes; and in many cases alternative methods are also given. Perhaps the best conclusion is that we have here to deal with a corpus the beginnings of which may go back to Liu An[7] in the −2nd century, but which grew as time went on. The most likely candidate for acceptance as the major contributor is in our opinion Thao Hung-Ching[15] very early in the +6th century.

Another book of interest in the *Tao Tsang* [17] (Taoist Patrology) is the *Hsien-Yuan Huang-Ti Shui Ching Yao Fa*[22] (Medicinal Methods of the Aqueous [Solutions] Manual of Hsien-Yuan the Yellow Emperor)[h]. So far we have not been able to trace its authorship or fix its date. It treats of all kinds of minerals subjected to more or less similar operations, e.g. triple extraction with water, hot extraction with "bitter wine" (i.e. vinegar), addition of copper sulphate or potassium nitrate to the extracts, mixing with numerous ingredients of vegetable origin, and burying in vessels underground. There are 32 recipes (with two missing), and besides the above methods they generally include evaporating to dryness on the water-bath. But having prepared aqueous solutions of mineral salts and the active principles of plants in a very reasonable pharmaceutical way, each recipe usually ends with the addition of the solution to metallic mercury and its conversion into silver thereby. Thus an alchemical layer seems to have been superimposed on a pharmaceutical layer. This book however, which so far has received no attention, deserves more than we are able to give it here.

III. Translation and Annotations

We now present a full translation of the *San-shih-liu Shui Fa* with annotations. There will then follow interpretations of the various procedures, in so far as we are able to visualize them.

[g] No. 923 in Wieger's Catalogue (39); hereafter referred to as W/923. On the Patrology itself, see further Ho & Needham (14).

[h] W/922.

San-shih-liu Shui Fa

(Thirty-six Methods for Bringing Solids into Aqueous Solution)

(1) (*Huang-*)*fan-shih*[23] *shui*—an aqueous solution of (yellow) alum (potassium iron double sulphate) or, alternatively, ferric sulphate[i].

(*a*) Take 1 lb. of (yellow) alum (*fan-shih*[9]) and select those pieces that are translucent (*wu tan*[24]) (lit. without gall) and (dented like) horse teeth. Put them inside a green bamboo tube, the walls of which are pared thin. After putting 4 oz. of nitre (*hsiao-shih*[12])[j] below and over (the alum), seal the opening (of the bamboo-tube) tightly. (The tube) being now immersed in vinegar (*hua-chhih*[25]) for 30 days, an aqueous solution will be formed. When more vinegar is mixed (with the solution) and it is then rubbed on iron, the iron will (look) like copper (*thung*[27])[k]. When it is used alone to treat iron acetate (*thieh-ching*[28])[l] an aqueous solution will (also) be formed.

(*b*) Take 3 lb. of (yellow) alum and seal it in a freshly-cut bamboo tube with thin walls by means of some silk floss. If (the tube) is buried for a period of 4 or 5 days an aqueous solution will be formed.

(*c*) The (yellow) alum is thoroughly soaked in vinegar and then mixed with 2 oz. of nitre. The container is sealed with lacquer[m] and buried 3 ft. below ground. An aqueous solution will form after 15 days.

(2) *Hsiung-huang*[10] *shui*—an aqueous solution of realgar[n].

(*a*) 1 lb. of realgar and 4 oz. of nitre are enclosed in a freshly-cut bamboo tube, which is sealed with lacquer and placed in vinegar for 30 days. An aqueous solution will be formed[o].

[i] The text mentions *fan-shih shui*[26] in two different places, cf. No. 7. The *Huang-Ti Chiu Ting Shen Tan Ching Chüeh*[5] (ch. 8, p. 2*b*), however, refers to this first method as the making of *huang-fan-shih shui*. *Huang-fan* now means yellow alum, but in the Sung period it meant ferric sulphate. Read & Pak (29), no. 133; hereinafter abbreviated as RP 133.

[j] *Hsiao-shih* is nitre (RP 125).

[k] This is assuredly a reference to the action of iron in precipating metallic copper from its salts, see the discussion, p. 144 below.

[l] Iron acetate, also black oxide of iron (RP 23).

[m] The reader is reminded that Chinese lacquer is derived from the latex of the lacquer-tree, *Rhus vernicifera*, and has nothing to do with the insect lac of India and Ceylon. Dried lacquer powder is used medicinally, but the main constituent of the substance itself, urushiol, which polymerizes, is quite poisonous and causes inflammation of the skin in many subjects until habituation occurs. Methods for keeping lacquer in solution are given in our text, p. 150 below.

[n] *Hsiung-huang* is realgar, As_2S_2 (RP 49).

[o] This method is also given in the *Pao Phu Tzu* (Nei Phien, ch. 16, p. 10*a*), the *Huang-Ti Chiu Ting Shen Tan Ching Chüeh* (ch. 8, p. 4*a*) and the *Chu Chia Shen Phin Tan Fa*[29] (ch. 1, p. 9*a*), but instead of 4 oz. only 2 oz. of nitre was used and the reaction was said to take 20 days.

(*b*) (The realgar) is mixed with 2 oz. of nitre and vinegar in a porcelain jar (*thang thi phing*[30]), which is then sealed and buried 3 ft. below ground. After 20 days an aqueous solution with a sweet taste and a turbid yellow colour will be formed[p].

(3) *Tzhu-huang*[31] *shui*—an aqueous solution of orpiment[q].

(*a*) 1 lb. of orpiment and 4 oz. of nitre are sealed in a freshly-cut bamboo tube with lacquer. If this is placed in vinegar for 30 days an aqueous solution will result[r].

(*b*) (Orpiment) with the addition of 2 oz. of alum and 2 oz. of nitre contained in a porcelain jar and buried 20 days will form an aqueous solution which tastes sweet and has a yellow colour[s].

(4) *Tan-sha*[11] *shui*—an aqueous solution of cinnabar[t].

(*a*) 1 lb. of cinnabar with the addition of 2 oz. of copper sulphate (*shih-tan*[13])[u] and 4 oz. of nitre, sealed inside a freshly-cut bamboo tube with lacquer and immersed in vinegar will form an aqueous solution in 30 days.

(*b*) (Cinnabar mixed with) 2 oz. of copper sulphate and 2 oz. of nitre, contained in a porcelain jar and buried for 30 days will form an aqueous solution which has a bitter taste and a red colour.

(5) *Tshêng-chhing*[32] *shui*—an aqueous solution of copper carbonate[v].

(*a*) 1 lb. of copper carbonate with the addition of 4 oz. of nitre and 2 oz. of mercury, sealed in a freshly-cut bamboo tube with lacquer and put in vinegar for 30 days will form an aqueous solution.

(*b*) (Copper carbonate) with 2 oz. of nitre contained in a porcelain jar and buried for 30 days will form an aqueous solution.

(6) *Pai-chhing*[33] *shui*—an aqueous solution of azurite[w].

(*a*) 1 lb. of azurite, mixed with rabbit blood (*thu hsüeh*[34]), enclosed in a bamboo tube and the whole put in vinegar for 50 days will form an aqueous solution.

[p] This method is also given in the *Huang-Ti Chiu Ting Shen Tan Ching Chüeh* (ch. 8, p. 4*a*).

[q] *Tzhu-huang* is orpiment, As_2S_3 (RP 50).

[r] This method is also mentioned in the *Huang-Ti Chiu Ting Shen Tan Ching Chüeh* (ch. 10, p. 3*a*).

[s] This method is also mentioned in the *Huang-Ti Chiu Ting Shen Tan Ching Chüeh* (ch. 10, p. 3*a*).

[t] *Tan-sha* is cinnabar, mercuric sulphide (RP 43).

[u] *Shih-tan* is copper sulphate (RP 87).

[v] *Tshêng-chhing* is malachite or green copper carbonate (RP 83).

[w] *Pai-chhing* is a pale blue basic copper carbonate (RP 86), or according to Tuku Thao's[34] *Tan Fang Chien Yuan*[35] (ch. 1), as interpreted by Fêng & Collier (13), p. 209, white malachite. *Cf.* de Mély (19), pp. 115, 228.

(*b*) (Azurite) with the addition of 2 oz. of nitre, contained in a porcelain jar and buried for 30 days will form an aqueous solution which tastes sour and has a blue colour.

(7) *Fan-shih*[9] *shui*—an aqueous solution of alum[x].

(*a*) 1 lb. of alum, 2 lb. of cinnabar and 1 lb. of nitre, sealed in a freshly-cut bamboo-tube with lacquer and put in vinegar for 100 days will form an aqueous solution.

(*b*) (Alum) mixed with an aqueous suspension of greenish mica (*yün-ying*[36] *shui*)[y] and 2 oz. of nitre, placed in a porcelain jar and buried for 30 days will form an aqueous solution which tastes bitter and has a dark bluish colour.

(8) *Tzhu-shih*[37] *shui*—an aqueous solution of magnetite[z].

1 lb. of magnetite, 1 oz. of realgar and 1 oz. of copper sulphate pounded together, sealed in a bamboo tube with lacquer and put in vinegar for 30 days will form an aqueous solution[aa].

(9) *Liu-huang*[38] *shui*—an aqueous solution of sulphur[ab].

(*a*) 1 lb. of sulphur, 1 pint (*shêng*[39]) of dew collected from mulberry leaves during the eighth month (*pa yüeh sang shang shuang*[40]) and 2 oz. of nitre, sealed in a bamboo tube with lacquer and put in vinegar for 30 days will yield an aqueous solution[ac].

(*b*) Sulphur suspended in vinegar (*shun-tshao*[41]) with the addition of 2 oz. of nitre and enclosed in a bamboo tube as before, but buried in the ground, will turn after 15 days into an aqueous solution, called *pao-thien-chih-cho*[42] ("Heaven-enveloping Potion").

(10) *Hsiao-shih*[12] *shui*—an aqueous solution of nitre[ad].

(*a*) Nitre pounded and sieved and allowed to stand in brine (*yen tzu*[43]), then sealed in a bamboo tube and buried 4 ft. 4 in. in the ground will form an aqueous solution after 5 days[ae].

[x] *Fan-shih* is potash alum (RP 131).

[y] *Yün-ying* is a kind of greenish mica (RP 39); *cf.* de Mély (19), p. 64.

[z] *Tzhu-shih* is magnetite, iron oxide (RP 76).

[aa] The same method is also mentioned in the *Huang-Ti Chiu Ting Shen Tan Ching Chüeh* (ch. 8, p. 4*b*).

[ab] *Liu-huang* is sulphur (RP 128).

[ac] The *Huang-Ti Chiu Ting Shen Tan Ching Chüeh* (ch. 10, p. 3*a*) gives the same method and also explains how the dew was collected saying: "Get a diligent boy to go out for it early in the morning. He must first wash his hands. The dew is then collected by soaking it up with clean silk floss."

[ad] *Hsiao-shih* is nitre, potassium nitrate (RP 125).

[ae] It is deliquescent anyway. Also mentioned in the *Huang-Ti Chiu Ting Shen Tan Ching Chüeh* (ch. 10, p. 2*a*).

(*b*) 3 lb. of nitre put in a freshly-cut bamboo tube with pared walls wrapped round with bamboo leaves and buried 4 ft. in the earth in a moist place, will give an aqueous solution after 5 days.

(*c*) (Nitre) treated with alligator blood (*thu lung hsüeh*[44])[af], sealed in a bamboo tube with lacquer and buried 3 ft. in the ground for 15 days will form an aqueous solution which has a bitter taste. This is known by the name *yang cho*[45] ("Yang Potion").

(11) *Pai-shih-ying*[46] *shui*—an aqueous suspension[ag] of quartz[ah].

1 lb. of quartz, 1 pint of crane blood (*ho tzu hsüeh*[47])[ai] and 4 oz. of nitre sealed in a bamboo tube with lacquer and put in vinegar for 30 days will form an aqueous suspension.

(12) *Tzu-shih-ying*[48] *shui*—an aqueous suspension of amethyst[aj].

1 lb. of amethyst and 4 oz. of nitre sealed in a freshly-cut bamboo tube with lacquer and put in vinegar for 40 days will yield an aqueous suspension.

(13) *Chhih-shih-chih*[49] *shui*—an aqueous suspension of red bole clay[ak].

1 lb. of red bole clay mixed with 1 pint of the blood of a black dog (*wu chhüan hsüeh*[50]) and 4 oz. of nitre, sealed in a bamboo tube with lacquer and put in vinegar for 30 days will form a suspension.

(14) *Hsüan-shih-chih*[53] *shui*—a suspension of graphite[al].

1 lb. of graphite and 4 oz. of nitre, sealed in a (bamboo) tube with lacquer and buried 5 ft. underground for 30 days will form a suspension.

(15) *Lü-shih-ying*[54] *shui*—a suspension of green rock crystal[am].

1 lb. of green rock crystal, 1 oz. of copper carbonate and 2 oz. of cinnabar sealed in a bamboo tube and put in vinegar for 100 days will form a suspension.

[af] *Alligator sinensis* blood; Read (26), no. 105.

[ag] We change the translation here for obvious reasons though the text says *shui*[51] as in all the other cases.

[ah] Quartz or rock-crystal (RP 40); *cf.* de Mély (19), p. 65.

[ai] A highly numinous animal in Taoist thought, a symbol of immortality, longevity, and unworldliness; *Megalornis japonensis*, Read (25), no. 245. The use of mammalian and avian bloods for the making of potable elixirs by a complicated method due to one Khang-Fêng-Tzu[52] is mentioned in *Pao Phu Tzu* (Nei Phien, ch. 4, p. 13*b*). See Feifel (11), p. 22.

[aj] *Tzu-shih-ying* is amethyst, hyaline quartz (silicon oxide) containing manganese, iron, etc. (RP 41).

[ak] *Chhih-shih-chih* is red bole, siliceous clay (RP 57*e*).

[al] No other reference to *hsüan-shih-chih* has yet been found. *Hsüan*[56], however, may mean "black" (*hei*[57]) and *hei-shih-chih*[58] is graphite; de Mély (19), p. 88.

[am] *Shih-ying*[59] refers to quartz or rock-crystal (RP 40). *Lü-shih-ying* probably refers to specimens of a greenish colour.

(16) *Shih-kuei-ying*[55] *shui*—an aqueous solution of chalk or fossils[an].

1 lb. of chalk or fossils and 1 pint of ginger juice contained in a bamboo tube and put in vinegar will form an aqueous solution after 10 days.

(17) *Shih-liu-tan*[64] *shui*—an aqueous solution of red sulphur[ao].

1 lb. of red sulphur and 1 lb. of magnetite pounded together, put in a bamboo tube and buried for 10 days and 10 nights will form an aqueous solution.

(18) *Tzu-ho-shih*[65] *shui*—a suspension of purple agate[ap].

Purple agate mixed with 1 pint of hemp-seed oil (*ma-chih*[66]) in a copper container will form a suspension after 10 days.

(19) *Hua-shih*[67] *shui*—an aqueous solution of marble, granite or steatite[aq].

1 lb. of the mineral and 2 oz. of cinnabar put in a bamboo tube and buried 10 ft. deep in the ground will form an aqueous solution after 10 days.

(20) *Han-shui-shih*[68] *shui*—an aqueous solution of gypsum[ar].

1 lb. of gypsum and 1 oz. of copper sulphate put in a bamboo tube and boiled (in water) for 1 day will form an aqueous solution.

(21) *Ning-shui-shih*[75] *shui*—an aqueous suspension of gypsum or calcareous spar[as].

1 lb. of calcareous spar mixed and pounded together with the blood of green ducks (*chhing fu hsüeh*[76]) and put in a bamboo tube will form an aqueous suspension when buried 3 ft. down in damp ground for 10 days.

(22) *Lêng-shih*[77] *shui*—an aqueous suspension of steatite[at].

1 lb. of steatite mixed with 1 lb.[au] of bat dung (*fu-i-shih*[78]), pounded together, put in a bamboo tube and buried for 100 days will form an aqueous suspension.

[an] This substance has not yet been identified. *Shih-kuei*[60] and *shih-ying*[61] are both mentioned in *Pao Phu Tzu* (Nei Phien, ch. 11, p. 1*b*); Feifel (12), p. 2. They have been identified as rock-crystal. *Pao Phu Tzu* (Nei Phien, ch. 11, p. 4*b*) also mentions a fossil or petrified fungus called *shih-kuei-chih*[62]. *Shih-kuei-ying* may therefore be either rock-crystal or some fossil form. The *Chin Shih Pu Wu Chiu Shu Chüeh*[63] (Explanation of the Inventory of Metals and Minerals according to the Numbers Five [Earth, Yang] and Nine [Metal, Yin]) (W/900) says that *shih-kuei-ying* is white in colour and comes off on the hand when touched. This sounds rather like chalk.

[ao] *Cf.* de Mély (19), p. 144. Ko Hung says it is a kind of sulphur; *cf.* Feifel (12), p. 8.

[ap] The word *ho*[69] is sometimes used as an equivalent to the word *chia*[70]. *Chia-shih*[71] is agate (impure quartz); Chang Hung-Chao (8), p. 160. *Tzu*[72] means purple.

[aq] *Hua-shih*[67] may be meant for *hua-shih*[73], which is marble (RP 58) or granite (Chang Hung-Chao (8), p. 164), or if meant for *hua-shih*[74], talc or steatite (RP 55).

[ar] *Han-shui-shih* is gypsum (RP 51), or calcareous spar (RP 119), in any case calcium sulphate, which is by no means insoluble anyway.

[as] *Ning-shui-shih* is gypsum, $CaSO_4$, or sometimes calcareous spar, calcite, $CaCO_3$ (RP 119).

[at] Steatite, argillaceous earth with magnesium silicate (RP 55).

[au] We emend to a weight measure as the text sometimes confuses the word *chin*[81] (1*lb.*) with the word *shêng*[39] (pint).

(23) *Hua-shih*[74] *shui*—an aqueous suspension of talc[av].

1 lb. of talc, 1 lb.[au] of mica and 1 lb.[au] of crude salt (*jung yen*[79]), put in a bamboo tube and buried for 10 days will give an aqueous suspension.

(24) *Huang-erh-shih*[80] *shui*—an aqueous suspension of calcite[aw].

1 lb. of calcite and 1 pint of dew collected from plants during the eighth month, contained in a bamboo tube and put in vinegar for 100 days will yield an aqueous suspension.

(25) *Chiu-tzu-shih*[83] *shui*—an aqueous suspension of conglomerate nodules or geodes[ax].

1 lb. of nodules mixed and pounded together with 1 pint of the sap of the stinking cedar (*shu chih*[84])[ay] and left in a copper container for 10 days will form an aqueous suspension.

(26) *Li-shih*[85] *shui*—an aqueous suspension or solution of gypsum[az].

(*a*) 1 lb. of gypsum and 1 pint of bamboo sap (*chu li*[86]), sealed in a bamboo tube with lacquer and buried 5 ft. underground for 30 days will form an aqueous suspension or solution.

(*b*) (The gypsum) is first thoroughly mixed with vinegar and allowed to stand. Charcoal in a metal pan is used to heat the substance for 3 days until the colour turns red; then the material is transferred to a bamboo tube, and 2 oz. of nitre added. The tube being sealed with lacquer is buried 3 ft. underground for 20 days. An aqueous suspension or solution will result.

(27) *Shih-nao*[88] *shui*—an aqueous suspension of haematitic nodules or geodes[ba].

1 lb. of nodules and 1 lb. of sulphur pounded together and sealed in a bamboo tube will form an aqueous suspension after being buried for 10 days.

(28) *Yün-mu*[89] *shui*—an aqueous suspension of mica[bb].

(*a*) 1 lb. of mica, boiled and crumbled into powder is mixed with 2 oz. of brine and 1 oz. of an aqueous solution of nitre until it is thoroughly mixed and allowed to stand. If then put in a bamboo tube and buried 5 ft. underground for 20 days an aqueous suspension will be formed.

[av] *Hua-shih* is talc (RP 55).

[aw] *Huang-erh-shih* is probably *huang-shih*[82], i.e. calcite, calcium carbonate (RP 54).

[ax] See the discussion, p. 148 below.

[ay] The "stinking cedar" *Ailanthus glandulosa* (*shu* or *chhu*)[87] is mentioned in *Pao Phu Tzu* (Nei Phien, ch. 4, p. 15*b*); *cf.* Feifel (11), p. 25, also Feifel (12), p. 16. Its leaves have medicinal properties, but the wood is usable only as fuel.

[az] *Li-shih* is a particular variety of gypsum (RP 52).

[ba] See the discussion, p. 148 below.

[bb] *Yün-mu* is mica (RP 39), complicated silicates of magnesium, aluminium, potassium, lithium, etc.

(*b*) (Mica) thoroughly mixed with an equal quantity of aqueous extract of cinnamon (wood) (*kuei*[90])[bc], brine and 2 oz. of nitre, sealed with lacquer in a bamboo tube and buried in the ground to a depth of 3 ft. as before, or put in a dry well and covered for 25 days, will form an aqueous suspension. This is put in a copper vessel and placed on moist ground. It is then known as *yün-ying-i*[92] ("mica juice")[bd] and can be used for dissolving *shih-chiu-ying*[93],[be].

(29) *Huang-chin*[94] *shui*—an aqueous solution of gold[bf].

1 lb. of gold and 2 lb. of green vitriol (*lü fan*[95])[bg], sealed in a bamboo tube with lacquer and placed in vinegar for 50 days will form an aqueous solution.

(30) *Pai-yin*[96] *shui*—an aqueous solution of silver[bh].

1 lb. of silver, 2 pints of clear wheat sauce (*mai chiang chhing*[97]), 2 pints of vinegar, and 1 pint of wine made from glutinous millet (*chhih shu*[98])[bi] and the fruits of the *mu ching*[99] shrub[bj]; sealed in a bamboo tube with lacquer and put in vinegar for 30 days will form an aqueous solution.

(31) *Chhien-hsi*[102] *shui*—an aqueous solution of lead[bk].

2 lb. of lead scrapings mixed with 4 oz. of nitre, sealed in a (bamboo) tube as before and put in vinegar will form an aqueous solution after 100 days.

(32) *Yü-fên*[103] *shui*—a suspension of jade powder[bl].

[bc] This is *Cinnamomum cassia*, that famous tree native to Kuangsi province; Read (27) no. 495. Note that apart from the use of its bark, twigs, buds, peduncles and oil in cooking and pharmacy, it had a reputation as an elixir constituent. It is often mentioned in this connection by Ko Hung in *Pao Phu Tzu*, e.g. Nei Phien ch. 11, p. 16*b*, the story of Chao Tha-Tzu[91]; see Feifel (12), p. 26.

[bd] The *Pao Phu Tzu* book has a parallel text on this subject in ch. 11, pp. 9*b* ff.; Feifel (12), p. 16. For bringing mica into solution or suspension Ko Hung recommends cinnamon wood, *tshung*[100] onion juice (see below), mercury, nitre, honey, and various other plant materials. See further on p. 147 below.

[be] No other reference to *shih-chiu-ying* has been found. It may mean *shih-ying*[61] which is quartz or rock-crystal (RP 37).

[bf] *Huang-chin* is gold (RP 1). *Huang-chin-shih*[101] is a synonym for realgar (RP 49).

[bg] Copperas, ferrous sulphate.

[bh] *Pai-yin* is silver (RP 2).

[bi] This is *Panicum miliaceum*, much used for food but also medicinal.

[bj] This is *Vitex negundo*, a medicinal plant; Read (27), no. 148.

[bk] The word *chhien-hsi* can refer to either tin or lead (RP 15), but the text implies that lead is meant.

[bl] *Yü*[108] is probably nephrite from Sinkiang (RP 29) since jadeite did not become common in China until late times. Both are crypto-crystalline silicates, the former of calcium and magnesium, the latter of sodium and aluminium. Fên[109] means powder. Ko Hung follows his statement in *Pao Phu Tzu* (ch. 3, p. 1*b*) already quoted (p. 123 above) by saying "To turn the 36 minerals directly into aqueous solutions, to soften jade to a sweetmeat, and make gold into an edible paste. . .".

(*a*) 1 lb. of jade powder, 1 lb. of peony ash (*shao-yao hui*[104])[bm], 1 pint of the blood of a white dog (*pai chhüan hsüeh*[105]) and 10 scarabaeid larvae (*chhi-tshao*[106])[bn] are first pounded together and compressed to remove the liquid before they are again pounded and sealed in a bamboo tube with lacquer. This is placed in vinegar for 30 days. An aqueous suspension will result.

(*b*) A piece of white jade looking like lard can be made smooth by rubbing with the blood of a toad (*shan shu hsüeh*[107])[bo]. When it is crushed to a powder, treated with the fruit of the small coarse pear (*thang-li shih*[112])[bp], nitre powder and a crushed toad, an aqueous suspension will be formed after 1 day and 1 night.

(*c*) (Jade powder) allowed to stand with alligator blood[bq] and an aqueous suspension of mica so as to make a damp mass, and put in a copper pan (*thung thiao*[113]) will form, after 1 night, an aqueous suspension called *yü chiang*[114] ("jade juice").

(33) *Chhi*[115] *shui*—an aqueous solution of lacquer[br].

(*a*) 1 pint of lacquer and 18 large crabs kept overnight (*ta su hsieh*[116])[bs], with the latter placed over the former, will still remain an aqueous solution after 50 days.

(*b*) 1 lb. of good quality lacquer contained in a copper vessel will remain an aqueous solution after 1 night when 18 crabs are added to it.

(*c*) 1 lb. of mica powder in lacquer will remain an aqueous suspension after 1 night.

(*d*) 3 lb. of white jade powder added to lacquer will form after 3 days an aqueous solution called *shen-chiang*[119] ("magical mush"). With this liquid one gains a far-reaching and penetrating sight, extending to the four seas—its limit knows no bound.

(34) *Kuei*[90] *shui*—an aqueous solution of cinnamon.

(*a*) 1 lb. of cinnamon powder and 3 pints of juice of the ciboule onion

[bm] *Paeonia albiflora*. Its root is used in pharmacy; Read (27), no. 536. This ingredient would have contributed some alkali.

[bn] References to these larvae of various kinds of dung-beetles (e.g. *Catharsius molossus* or *Geotrupes laevistriatus*) go back far in Chinese literature, including the *Huai Nan Wan Pi Shu*[110]; *cf.* Ho & Needham (15). See the extensive account in Read (28), pp. 105 ff., 120 ff., which reproduces Li Shih-Chen's[111] account of the medicinal uses.

[bo] Also read *chhan chhu*. This is the common toad *Bufo* spp.

[bp] *Pyrus betulifolia*; Read (27), no. 432.

[bq] See p. 128 above.

[br] *Chhi* is, as we have seen the latex of the lacquer-tree *Rhus vernicifera*; Read (27), no. 318.

[bs] Probably fresh-water *Eriocheir sinensis*. The term *su*[117] here means "kept overnight", as one can see from *Hsieh Phu*[118], ch. 2, p. 5*a*, so the crabs were not to be too fresh. No doubt a certain amount of autolysis enhanced the action of their tissues.

(*tshung thi*[120]) put in a bamboo tube and steamed for 3 days and 3 nights will form an aqueous solution[bt].

(*b*) Cinnamon in broken pieces is treated with the juice of the ciboule onion until it is thoroughly soaked, and then mixed with dew from the mountains, rain-water, snow, or water from a long river. If the mass is warmed in a sealed bamboo tube with nitre, using 2 oz. of nitre for every lb. of cinnamon, finally being steamed in a steamer[bu] for 3 days and 3 nights, an aqueous solution called *mu shih tê*[121] will result.

(35) *Yen*[124] *shui*—brine.

Common salt is thoroughly stirred in water, sealed in a bamboo tube with thin walls and buried 4 ft. 4 in. down in damp ground. After 4 days brine will be formed[bv].

These thirty-six[bw] methods for bringing solids into aqueous solution are abbreviated from the old treatise so as to give only the essentials. As they are simple they can be followed and put to use. Among the many solids there are some which are unknown to the world. It is not necessary to include all of them. The fifteen headings marked with red dots are those suggested in later times[bx]. They are mentioned together with (the earlier ones) because the names of the solids concerned are similar.

(36) *Shih-tan*[13] *shui*—an aqueous solution of copper sulphate[by].

1 lb. of copper sulphate is thoroughly mixed with vinegar, 2 oz. of nitre scattered on top and the whole sealed in a bamboo tube with lacquer. It is then placed in a small porcelain jar containing some vinegar and buried 3 ft. in

[bt] The *Pao Phu Tzu* (Nei Phien, ch. 11 p. 12*b*) says that cinnamon can be changed into liquid by steaming it together with the juice of this onion; an elixir results. See Feifel (12), p. 20. The ciboule onion is identified as *Allium fistulosum*; in mediaeval Chinese geobotanical prospecting, its presence advertised the existence below of silver ore. See on this Needham (21), vol. 3, pp. 675 ff.; Needham (22). We cannot be sure what part of the tree *Cinnamomum cassia* was being used in these experiments but we think it was the wood, for according to the *Ming I Pieh Lu*[122] quoted in *Pên Tshao Kang Mu*[123] (ch. 34, p. 18*a*) if one eats the wood for a long time one will become one of the Holy Immortals enjoying perpetual youth.

[bu] On these pieces of apparatus, so characteristic of Chinese alchemical laboratories as well as Chinese kitchens, see Ho & Needham (14).

[bv] This method is also mentioned in the *Huang-Ti Chiu Ting Shen Tan Ching Chüeh* (ch. 10, p. 3*a*), but its significance is not obvious.

[bw] The text gives only 35, so there must have been an omission in the compiling of this version. Note the tendency to more fanciful nomenclature in the following 7 entries.

[bx] It is unfortunate that the red dots mentioned have not been reproduced in the text handed down to us.

[by] *Shih-tan* is copper sulphate (RP 87). It would be readily soluble anyway.

the ground for 15 days. An aqueous solution called *yün-liang-shih-cho*[125] ("the Potion of the Cloud Bridge Mineral") results.

(37) *Thung-chhing*[126] *shui*—an aqueous solution of copper acetate[bz].

Copper acetate in 5 cups of water, mixed with 2 oz. of nitre, sealed in a bamboo tube with lacquer, and buried for 15 days will form an aqueous solution. After steaming this is called *hua lung hsi*[111] ("the Tide of the Elegant Dragon"). In appearance it resembles green jade (*chhing pi*[128]). It is also called *yün ying cho*[129] ("the beautiful cloudy Potion").

(38) *Jung-yen*[79] *shui*—an aqueous solution of lake or rock salt[ca].

1 lb. of salt is thoroughly mixed with alligator blood[cb], sealed in a bamboo tube with lacquer after the addition of 3 lb. of nitre and buried in the ground to a depth of 3 ft. for 15 days. An aqueous solution will result.

(39) *Lu-hsien*[130] *shui*—an aqueous solution of crude lake salt[cc].

Some salt is mixed with vinegar until damp before being put into an iron vessel and heated over a charcoal fire for 3 days and 3 nights. While (the vessel) is still red(-hot) the contents is taken out and nitre immediately added. 2 oz. of nitre are used for every lb. (of salt). These are sealed with lacquer in a bamboo tube and buried 3 ft. in the ground for 15 days. An aqueous solution called *chin-liu-i*[131] ("Golden Current Liquid") is formed.

(40) *Thieh-hua*[132] *shui*—an aqueous solution of iron acetate[cd].

Iron acetate mixed with mica, brine and nitre—using 2 oz. of nitre for every lb. of iron acetate—is put into a bamboo tube and sealed with lacquer. The tube is put in a porcelain jar containing vinegar. The jar is buried 3 ft. underground for 45 days. An aqueous solution called *hsüan-ling-chin-tzhu-hsi-shui*[111] ("Mysterious golden compassionate Tide Liquid") is formed. (This liquid) makes a man immortal.

(41) *Chhien-kung*[134] *shui*—an aqueous solution of lead[ce].

5 spoonfuls of "flying frosty snow" (*fei-shuang hsüeh*[135])[cf] are well mixed first with "elegant powder of the Metal Elder" (*chin wêng hua fên*[136])[cg] until damp, and then with mica and brine and (finally) nitre, using 2 oz. of nitre for every lb. (of lead powder). Sealed with lacquer in a bamboo tube, placed in

[bz] Basic copper acetate; de Mély (19), p. 26.

[ca] Lake or rock salt (RP 116).

[cb] See p. 128 above.

[cc] Crude lake salt (RP 118).

[cd] *Thieh-hua-fên*[137] is ferrous acetate (RP 24).

[ce] *Kung*[138] generally refers to the iron hub-bearing of a cart-wheel. *Chhien*[139] is lead.

[cf] Undoubtedly some white sublimate but we cannot identify it.

[cg] Certainly lead carbonate, though this technical phrase is somewhat unusual. *Chin wêng* = *chin kung*[140] = *chhien* (Pb). *Chhien hua*[141] is lead carbonate.

a jar of vinegar, and buried 3 ft. in the ground, the whole being kept warm by means of burning horse-dung; an aqueous solution will be formed after 30 days.

(42) *Kung*[138] *shui*—an aqueous solution of lead and mercury[ch].

"Accumulated snow" (*chi hsüeh*[142])[ci] is thoroughly mixed with metallic lead (*huang-chhing*[143]) and mercury. 3 oz. of mercury are used for every lb. of "lead powder". The substances are sealed with lacquer in a bamboo tube and this is put into a jar of vinegar. (The jar) is then buried 3 ft. in the ground. After being warmed with burning horse-dung for 30 days it will form an aqueous solution called *liu ching*[144] ("Flowing Silence"). If one follows this procedure and performs (the experiment) in a secluded place, one will always meet with success.

(The rest of the text deals with ritual procedures and dates inauspicious for the experiments. The translation is omitted in order to save space.)

IV. Discussion

It will easily be seen that the types of solubilization reaction described in this book are rather multifarious. They can however be divided without difficulty into a number of groups which it will be convenient to discuss separately.

(*a*) The Use of a Mineral Acid

As we noted in the introduction, the *Huang-Ti Chiu Ting Shen Tan Ching Chüeh*[5] makes a very significant statement about the 36 *Shui Fa*[145]. It says, "The transformation of alum, realgar and cinnabar into watery (solutions) follows the manual of Pa Kung[6]. All the methods depend upon the use of nitre for their successful achievement, only in the case of cinnabar, copper sulphate is (also) needed." Although this makes no mention of vinegar, it is clear that in most cases explicit directions are given for its addition. Thus both substances are present in 17 recipes, and one or other of them in 31 recipes out of the total of 42. One may suspect that in the 7 where nitrate alone is mentioned and in the 7 where vinegar alone occurs, it was the original intention to direct the use of both, but one or the other dropped out in copying. At the same time there are examples where only one reagent would have been quite effective, e.g. recipes (8) and (24). In other examples, e.g. recipe (1*b*) and (17) it seems certain that nitre and vinegar were originally in the text but fell out later, otherwise the procedure could not make sense. In others again

[ch] *Kung* generally refers to the iron hub-bearing of a cart-wheel, but here the text implies that lead and mercury are meant.

[ci] Again probably some unidentified white sublimate.

neither reagent was necessary, though both are given, e.g. recipes (36) and (40), or nitre only, e.g. recipes (37) and (38)[cj]. In any case the reactions with which we are chiefly concerned were nothing more nor less than the oxidation of the compounds or elements by dilute nitric acid, just as might be done in a modern chemical laboratory.

Most of the reactions of this group described in our text are quite plausible, involving oxidation of the insoluble sulphides of arsenic and mercury, insoluble elementary sulphur and the insoluble metals, by the action of nitrate in the presence of acetic acid. However, (i) the acidity arising from the acetic acid was extremely low and hence the rate of reaction correspondingly sluggish, requiring weeks instead of minutes; and (ii) in most cases water and H^+ (and its anion, i.e. Ac^-) were not directly added to the solids, but reached them by diffusion through the thick though pared-down bamboo "membrane" which constituted the reaction vessel, so that again the reactions were necessarily slow. No doubt some of the reaction products also diffused outwards as ions and became lost in the surrounding vinegar. But this did not worry the alchemists, because their primary concern was to see the insoluble solids disappear and change into aqueous liquids. The nature of the changes and that of the products formed was beyond their conjecture.

Where colloidal sulphur constituted part of the reaction products, this would be left inside the bamboo tube because the particle size would have been too large for free diffusion. The bamboo vessel therefore acted as a "semi-permeable membrane" retaining these colloidal products. It may be that this is why the alchemists were able to observe the yellow colour and the turbidity of the resulting solutions. Of course, the reactions carried out in porcelain or metal vessels involved the prior addition of vinegar and took place in essentially closed systems.

We shall now deal individually with some of the aqueous solutions prepared using nitrate and vinegar. We shall generally omit in our equations ions that appear on both sides of the equal signs so as to show the basic oxidation-reduction reactions. In the case of recipe (1) since ferric sulphate, $Fe_2(SO_4)_3$, is soluble in water anyway it would seem probable that yellow iron alum was originally the substance meant. The dissolved products would then presumably be a complex mixture of potassium and iron acetates and nitrates. Alum also occurs in recipe (7); presumably some would dissolve as such in the weak acid. The *Huang-Ti Chiu Ting Shen Tan Ching Chüeh* (ch. 10, p. 2*a*) gives a method for the making of *chhing-fan-shih shui*[146] which would be an aqueous solution of green vitriol (copperas) or ferrous sulphate. It says:

[cj] Recipe no. 39 is very curious for the acetic acid seems to have been driven off by heat before the nitrate was added, but the salt was soluble to begin with.

> "Take some *wu-fan*[147] alum and out of it select 1 lb. of the blue pieces. First keep them in good vinegar until thoroughly macerated and then put them in a container together with 2 oz. of nitre. Seal the container with lacquer and bury it 3 ft. below ground for 15 days. An aqueous solution will form spontaneously."

Here again since the salt itself is quite soluble, probably some kind of alum was what was originally intended.

Another iron recipe is no. 40 which starts with ferrous acetate, not difficult to dissolve but oxidizing probably under the conditions given to a blood-red solution of the basic acetate, precipitable by heating. This, if dilute, would explain the colour description in the alchemical name of the product.

The magnetite recipe (8) gives us something different, for nitrate is absent. Here the magnetic iron oxide must have been acting as oxidizing agent and the realgar as reducing agent, giving iron sulphate, arsenate or arsenite. For example it might be plausible to write an equation as follows:

$$3Fe_2O_3 + As_2S_2 + 18HAc \rightarrow 6Fe^{++} + 2S + 2As^{+++} + 18Ac^- + 9H_2O$$

Since Fe_3O_4 can be regarded as $FeO.Fe_2O_3$, only the oxidized part Fe_2O_3 is considered for simplicity.

Continuing our examination of the series of solutions of salts of metals we come to copper carbonate in recipes (5) and (6). Here mercury can have performed no function. Copper carbonate is of course soluble in weak nitric acid. The recipe is repeated in the *Pên Tshao Kang Mu Shih I*[148] (ch. 1, p. 12*a*) where it is ascribed to Chu Chhüan's[149] *Shen Yin*[150].[ck] It is recommended as an eye-lotion—very understandably in view of the oligodynamic action of copper.

The lead salt recipe (41) is embarrassed by uncertainty as to the identification of the reactants, though lead carbonate, used in China from very ancient times as a cosmetic, was certainly present. If the "flying frosty snow" was calomel or corrosive sublimate, as seems very probable, the mercury might have acted as a catalyst in the oxidizing reactions whereby basic lead acetate and a little lead nitrate were produced, besides the adjuvant action of hydrochloric acid. The process was the converse of the second stage of the classical manufacture of white lead, which appears to have been known and used in China as far back as the —4th century, i.e. at least as early as the first European description of it by Theophrastus[cl]. The recipe would certainly have yielded a very poisonous drink, so it may be significant that aspirants for immortality were not counselled to consume it.

[ck] See immediately below.

[cl] Evidence will be given in Needham (21), vol. 5. Here we need only cite the complete statement in the *Chi Ni Tzu*[151] book, ch. 3, p. 1*b* (in *Yü Han Shan Fang Chi I Shu*, ch. 69, p. 24*b*).

The solubilization of elementary metals by nitrate and vinegar, e.g. recipes (29), (30), (31) and (42) might be represented as follows:

(i) for lead and iron

$$3Pb + 2NO_3^- + 8H^+ \text{ (from vinegar)} + (2K^+) + (8Ac^-) \rightarrow 3Pb^{++} + 2NO + (2K^+) + (8Ac^-) + 4H_2O$$

(ii) for silver

$$3Ag + NO_3^- + 4H^+ + (K^+) + (4Ac^-) \rightarrow 3Ag^+ + NO + 2H_2O + (K^+) + (4Ac^-)$$

Generally, then, mixed acetates of the metals and alkali metals remained in solution, while a certain amount of nitric oxide was given off. In recipe no. 42 we find the additional presence of mercury with metallic lead. The resulting amalgam would certainly have speeded up the process. One cannot feel that the gold recipe (29) gave the alchemists much satisfaction, however, even if nitrate was present.

Now comes the alchemically important solubilization of mercuric sulphide, recipe no. 4*a*. The reaction appears to have been either

$$3HgS + 2K^+NO_3^- + 8HAc \rightarrow 3S + 3Hg^{++} + 2NO + 2K^+ + 4H_2O + 8Ac^-$$

or

$$3HgS + 8K^+NO_3^- + 8HAc \rightarrow 3SO_4^{--} + 8NO + 8K^+ + 3Hg^{++} + 4H_2O + 8Ac^-$$

As for the function of the copper sulphate (especially mentioned in the *Huang-Ti Chiu Ting Shen Tan Ching Chüeh*) we think that it could well have been a catalyst.

The reaction in recipe no. 4*b* is similar to the preceding one, but the red colour demands an explanation. We suggest that it was due to the presence of selenium as an impurity. Selenium and sulphur are so similar in their properties that they belong to the same group in the Periodic Table. When acidified most selenium compounds are decomposed to form elementary selenium which is brilliantly red. Recipe (4*b*) omits vinegar, perhaps unintentionally.

So important did the alchemists consider the bringing into solution of mercuric sulphide that mention of it can be found in a number of other texts. As an example we may give the following. *Pao Phu Tzu* about +300 gives the same recipe as (4*a*) but with a different proportion for nitre[cm]. The same method is mentioned in the *Huang-Ti Chiu Ting Shen Tan Ching Chüeh*[cn] and the *Chu Chia Shen Phin Tan Fa*[co]. Both of these are primarily Thang or

[cm] Nei Phien, ch. 16, p. 9*a*, *b*.
[cn] Ch. 8, pp. 4*a*, *b*.
[co] Ch. 1, p. 8*a*.

Sung texts, but an earlier reference, lesser known, occurs in the *Shang Chhing Chiu Chen Chung Ching Nei Chüeh*[152] (Confidential Explanation of the Interior Manual of the Nine Adepts; a Shang-Chhing Scripture), W/901, p. 1*a*. This book bears the name Chhih-Sung Tzu[153], a pseudonym of the +4th century alchemist Huang Chhu-Phing[154], and there is nothing in the content to suggest a later date. Apart from descriptions of the effects of elixirs, and directions about the auspicious and inauspicious days for embarking on the Great Work, together with details of necessary sacrificial offerings, only one practical method is given, namely the bringing of cinnabar into solution by long heating with vinegar, with or without the addition of lacquer latex. In the omission of nitre this recipe resembles (8) but no copper sulphate is present. Perhaps however mercuric acetate was slowly formed. Conversely, the vinegar is omitted in the formula of Chao Hsüeh-Min[155] in his *Pên Tshao Kang Mu Shih I*[148] (Supplementary Amplifications of the Great Pharmacopoeia)[cp] of +1769 which includes only cinnabar, copper sulphate and nitrate exactly as in (4*b*). One cannot help wondering whether here again the mention of vinegar was not accidentally omitted. It is interesting that Chao quotes the recipe as coming from the *Shen Yin*[150] (Book of Mysterious Hidden Things) by the famous Ming prince Chu Chhüan[156] (+1390 to +1448), alchemist, botanist, geographer and musician. Chao adds that the solution (mainly mercuric acetate) prolongs life, dispels evil influences, nourishes the spirits and calms the mind.

The sulphur waters, recipes (9) and (17), recall the sulphur-containing liquids beloved of the Greek alchemists[cq]. Apparently the "divine" or "sulphur water" (*το ὑδωρ του θεῖου*), prepared from chalk, sulphur, vinegar, and ammoniacal urine, contained calcium polysulphides, very striking in their effects for the ancients because capable of giving coloured precipitates with metal salts, tinting the colours of metals in various ways, and even attacking the noble metals. Here in the *San-shih-liu Shui Fa* we find again the use of vinegar. In (9*a*) the nitric acid available would only oxidize a small proportion of the sulphur present, but as the reaction-vessel was not buried atmospheric oxidation to sulphates catalyzed by nitrous anhydride N_2O_3 could have occurred. The change would presumably be:

$$S + 2K^+NO_3^- \rightarrow 2K^+ + SO_4^{--} + 2NO$$

If the "dew" in (9*a*) contained much organic matter, bacterial reduction to sulphides might have followed. We shall return presently to the role of organic ingredients but the effect of bacterial action may have been particularly important where sulphur was concerned. Thus in recipe no. 21 where calcium

[cp] Ch. 1, p. 11*b*. This chapter would greatly repay further investigation.

[cq] Berthelot (2), pp. 46, 47, 68, 69, 139, etc. The recipes are first found in the Leiden papyri of the +3rd century—not much earlier than our own text.

sulphate was suspended with duck blood the putrefying bacteria would undoubtedly reduce the sulphate to calcium sulphide and then to the hydrosulphide and polysulphides, together with some carbonates.

Recipe no. 2*a* is a good case of getting arsenic into solution. Presumably the sulphide and the nitrate formed arsenate or arsenite. It is possible to write out the oxidation-reduction reaction as follows:

$$3As_2S_2 + 22K^+NO_3^- + 4H_2O \rightarrow 6AsO_4^{---} + 6SO_4^{--} + 22NO + 8H^+ + 22K^+$$

Under the conditions of (2*b*) the sulphur seems to have been oxidized not to sulphate, but to free sulphur. For example:

$$3As_2S_2 + 10K^+NO_3^- + 4H_2O \rightarrow 6AsO_4^{---} + 6S\ (\text{colloidal sulphur}) + 8H^+ + 10K^+$$

In this way the turbid yellow colour and the sweet taste may be explained. When orpiment was used, recipe (3*a*), the reaction was probably:

$$3As_2S_3 + 28K^+NO_3^- + 4H_2O \rightarrow 6AsO_4^{---} + 9SO_4^{--} + 28NO + 8H^+ + 28K^+$$

In (3*b*) the yellow colour was again no doubt due to colloidal sulphur. The alum added very probably affected the pH of the medium, thereby controlling the stage of oxidation and giving an arsenite. A possible reaction would be:

$$3As_2S_3 + 8K^+NO_3^- + 2H_2O \rightarrow 6AsO_3^{---} + 9S + 8NO + 4H^+ + 8K^+$$

(*b*) Saltpetre as a Limiting Factor in East and West.

So much for the study of the oxidation-reduction reactions described in our text. Only two points remain to be mentioned. First, it gives us rather striking evidence for the familiarity of the Chinese alchemists with potassium nitrate (*hsiao-shih*) at least as early as the +5th century. Indeed it looks as if this goes back to one of the oldest lists of reagents existing in Chinese literature, that in the *Chi Ni Tzu*[151] book, a text which may be fairly confidently ascribed to the −4th century[cr]. One cannot be sure however, for the technical term may suffer from the same ambiguity as *nitron* in the ancient west[cs], and may

[cr] Ch. 3, p. 3*a*; in *Yü Han Shan Fang Chi I Shu*[157], ch. 69, p. 36*a*. On the *Chi Ni Tzu* (or *Fan Tzu Chi Jan*[158]) see Needham (21), vol. 2, pp. 275, 554.

[cs] On this subject and the history of saltpetre in general see the classical book of Reinaud & Favé (33), pp. 14 ff.; Bailey (1) vol. 1, pp. 49 ff., 169 ff., 173; and the new essay of Partington (44).

in Chhin and Han have meant carbonate rather than nitrate. However, substances in this position can only be judged by their deeds, and the present tractate clearly shows that by the Chin and Liang *hsiao-shih*[12] meant nitrate. Besides, it will be remembered from several pieces of evidence given in the present paper that the *shui fa* were considered to go back to Pa Kung and Liu An in the —2nd century. By +970 in the *Khai-Pao Pên Tshao*[207] Ma Chih[208] could define the very term as originating from the properties of the substance, saying: "Because it dissolves and transforms minerals therefore it is called 'solve-stone' "[ct].

All this throws valuable further light on the long-known evidence for the primary invention of gunpowder in China. It seems that lack of saltpetre in the West was one of the great limiting factors for this development, and it cannot be traced back with certainty before the time of the pharmacist Ibn al-Baithār (d. +1248) and the military writer Ḥasan al-Rammāḥ (ca. +1290). Correspondingly, the oldest mentions of gunpowder in Europe appear to be of the +13th century, preceding its general introduction in the +14th. In China, on the other hand, we have the first reference to the gunpowder mixture in the +8th or +9th century, its appearance in war early in the +10th, and its widespread use in the +11th and +12th before it reached Europe in the +13th or +14th[cu].

Secondly, we have here a chapter in the earliest history of the use of the mineral acids, not as isolated and purified products, but as part of a procedure quite ancient and primitive in that distillation was not involved. If nitric and hydrochloric acids were only to appear as such as the products of distillation, sulphuric acid could also be obtained by the simple combustion of sulphur[cv]. It is generally accepted that mineral acids were quite unknown to the ancients in the West or to the Arabic writers.[cva] The first account of the making of nitric acid (*aqua fortis*) is often said to occur in the Geberian *De Inventione Veritatis*[cw], a treatise originally attributed to the elusive Arab Jābir ibn Ḥaiyān, but

[ct] *Pên Tshao Kang Mu*, ch. 11, p. 25*a*.

[cu] The full evidence will be given in Needham (21), vol. 5, pt. 1.

[cv] But it was not until the +17th century that the "oil of sulphur" resulting was recognized as identical with the "oil of vitriol" produced by distilling cupric or ferrous sulphate. Neither product seems much to antedate +1530.

[cva] The question is of course not finally settled. The late Dr. E. J. Holmyard maintained that the preparation of nitric acid is to be found in the Jābirian corpus (+ 10th century), but so far as we know the text has never been published. Moreover, Professor J. R. Partington draws our attention to certain passages in the Greek alchemical writings, especially Zosimus, which can also be interpreted, if a little uncertainly, in this sense.

[cw] Ch. 23; Russell tr., p. 223, Darmstädter tr., p. 113. On the Latin Geberian corpus in general, *cf.* Sarton (36), vol. 2, p. 1043.

probably compiled in the West at the beginning of the +14th century. Partington however has shown that it is first found in the *Pro Conservanda Sanitatis* of the French Franciscan Vital du Four, ca. +1295[cx]. It was always a matter of distilling nitrate with alum and ferrous sulphate. Sulphuric acid (as oil of vitriol) came a good deal later, perhaps at the beginning of the + 16th century, and hydrochloric acid not until +1640.[cy] Thus the availability of saltpetre must again have been the primary limiting factor. It is interesting that the new recognition of a salt long known in East Asia[cz], and the transmission of the technique of its purification, should have permitted two developments in the West each so important as the manufacture of gunpowder and of nitric acid.

The absence of nitrate from the reagents of the early mediaeval West restricts the significance of the references to acetic acid in the Greek alchemical texts. Such allusions there certainly are, e.g. in the +5th-century tractate of John the Archpriest which speaks of the strongest white vinegar (τὸ λευκὸν ὄξος δριμυτατον)[cza], and in the probably +8th-century *Practice of the Emperor Justinian*[czb]. Von Lippmann was doubtless right in rejecting the speculation of Berthelot that such words concealed the use of crude mineral acids, and Greek texts which distinctly mention these, together with nitrate, are plausibly to be dated not earlier than +1300[czc].

At what time *aqua fortis* was first known in China we cannot yet say, but the following story suggests the possibility of some interesting researches on the borderline between Chinese and Indian chemical technology. In the former culture-area at any rate all the *dramatis personae* were ready to play their parts as early as the Thang period, from which this story dates; if not considerably earlier. The alums had been known since the −4th century[da], nitrate occurs also in the time of Ko Hung and with certain identification in the present text, and both ferrous sulphate (*lü-fan*[95]) and sal ammoniac (*nao-sha*[159])[db], (for the

[cx] *Cf.* Sarton (36), vol. 3, p. 531.

[cy] On the history of the industrial preparation of the mineral acids see Sherwood Taylor (38), pp. 90 ff, 99.

[cz] It will be remembered that one of the +13th century Arabic terms for saltpetre was *thalj al-Ṣīn*, "Chinese snow".

[cza] Berthelot (2), vol. 2, p. 266; vol. 3, p. 255; *cf.* von Lippmann (18), p. 71.

[czb] Berthelot (2), vol. 2, p. 386; vol. 3, p. 369; *cf.* von Lippmann (18), p. 114.

[czc] Berthelot (2), vol. 2, pp. 326, 332, 333; vol. 3, pp. 312, 317, 318; *cf.* von Lippmann (18), p. 114.

[da] *Chi Ni Tzu*, ch. 3, p. 3*a* (in *Yü Han Shan Fang Chi I Shu*, ch. 69, p. 26*a*).

[db] There is a +2nd-century mention of this in Wei Po-Yang (*Chou I Tshan Thung Chhi Fên Chang Chu Chieh*[162], ch. 2, p. 26*b* (ch. 30); *Tshan Thung Chhi*[163], *Tao Tsang* ed. W/990, ch. 2, p. 35*b*), where advice is given not to put ammonium chloride on ulcers.

making of *aqua regia*), appear in the *Thang Pên Tshao*[160] of +660[dc]. Adequate stills had by then long been in existence in China[dd]. There is thus much reason for anticipating that further research will uncover evidence of the preparation of nitric acid and a mixture of nitric and hydrochloric acids in China well before the +13th century and perhaps as far back as the Thang. A search in the Sung alchemical literature may well prove fruitful. Now for the story.

Wang Hsüan-Tshe[166] was an official who left China in +648 as ambassador to the court of Magadha (modern Patna) where at that time Harsha Vardhana, the friend of Hsüan-Chuang[167] the great pilgrim, was reigning. But at this time Harsha died and a usurping minister (A-Lo-Na-Shun[168] in the Chinese records) thought fit to attack the Chinese party, plunder their goods, and kill most of Wang's retinue. Wang, however, was a man of resource; he escaped to the mountains, made contact with the Kings of Nepal and Tibet, who were at that time allied with China, and descending again with an army of considerable size, gave battle to the usurper and completely overthrew him. The ambassador then returned home by another route, taking with him the usurper and other Indian prisoners, whom he presented to the emperor at Chhang-an (modern Sian) with a report on his proceedings.

An account of this, written a little over two centuries later, is of great interest, as it preserves what may be one of the earliest passages on mineral acids. In the *Yu-Yang Tsa Tsu*[169] of Tuan Chhêng-Shih[170] written in +863 we read[de]:

> "Wang Hsüan-Tshê[166] captured an Indian prince named A-Lo-Na-Shun. He had with him a scholar versed in arts and gramarye named[df] Na-Lo-Mi-So-Po[171], who said he was two hundred years old. (The Emperor) Thai Tsung was very interested and invited him to live in the Chin-Yen Mên[172] (Palace), to make the drugs for prolonging life. The Emperor asked the Minister of War, Tshui Tun-Li[173], to be in charge of it. (The Indian) said, 'In the country of the Brahmins there is a substance called *Pan-Chha-Cho Shui*[174] (Pan-Chha-Cho water)[dg] which is produced in

[dc] *Pên Tshao Kang Mu*, ch. 11, pp. 31*a*, 53*b*. A very important text, the *Chen Yuan Miao Tao Yao Lüeh*[164] (Classified Essentials of the Mysterious Tao of the True Origin of Things, W/917) mentions both nitrate and sal ammoniac. This is the text which has the first mention of the gunpowder formula. Though this itself is probably of the +8th or +9th century, the older parts of the book go back to the time of the putative author, Chêng Ssu-Yuan[165], in the +4th century.

[dd] See Ho & Needham (14).

[de] Ch. 7, p. 7*a*. A parallel account in the *Chiu Thang Shu*, ch. 198, p. 12*b*, tells how the emperor scoured the country to collect minerals and drugs for Na-Lo-Mi-So-Po's experiments, but that when the elixirs were completed they did not prove very effective, so eventually he was sent back to his own country. The *Chiu Thang Shu* was not completed till +945 but it was based on official archives and documents.

[df] The Indian form Nārāyaṇasvāmin has been conjectured.

[dg] "Punjāb water" has been conjectured, others think *phāṇṭa* water, i.e. a liquid prepared by filtration.

> the mountains in stone vessels, has seven varieties of different colours, is sometimes hot, sometimes cold, can dissolve herbs, wood, gold and iron —and if it is put into a person's hand, it will melt and destroy it. If you want to collect this water you have to use a 'camel's skull' placed in a stone vessel, and pour it out into a gourd[dh]. Whenever this water is present there are also stone columns looking like men guarding it. Anyone from another mountain who shows the way to this water will die. . . . Finally the Indian died in Chhang-an."

One of the best things about this account is date, which is very firm. Foreshadowing perhaps the later "alkahest" or universal solvent of Paracelsian chemistry, this passage suggests at any rate that a mineral acid was known in the +7th century. It gives some colour to the hints about strong acids in Ray's history of chemistry in India. The *Rasārṇava Tantra* (dated by Renou & Filliozat as of the +12th century)[di] speaks of the "killing" of iron and other metals by a *viḍa* (solvent?) which is prepared from green vitriol (*kāsīsa*), pyrites, etc.[dj] From the *Rasaratna-samuccaya* (compiled according to Renou & Filliozat about +1300) which reproduces material from the *Rasendra-cūdamaṇi* of Somadeva (+12th or +13th century), the process of "killing" certainly seems to be the formation of salts from metals[dk].

(*c*) Precipitation of Metallic Copper from Solutions of its Salts by Iron

In recipe (1) we are told that "when more vinegar is mixed with (the solution) and it is then rubbed on iron, the iron will (look) like copper". Since the method concerns the solubilization of iron alum, or perhaps ferric sulphate, the statement is meaningless as it stands but it has undoubtedly strayed in here from a discussion of copper sulphate (so often confused with alum on account of a similarity of nomenclature, *fan-shih*[9] and *tan-fan*). Nevertheless the words are of great interest for they concern an industrial process very old in China, namely the winning of metallic copper by precipitation from solutions of its salts in the presence of metallic iron.

In +1086 the great scientific scholar Shen Kua[175] (+1030 to +1094) wrote in his *Mêng Chhi Pi Than*[176] (Dream Pool Essays) the following passage:[dl]

> "In the Chhien-shan district of Hsin-chou there is a bitter spring which forms a rivulet at the bottom of a gorge. When its water is heated it becomes *tan-fan*[dm]. When this is heated it gives copper. If this 'alum'

[dh] Could this be a veiled reference to distillation?
[di] Vol. 2, p. 169.
[dj] Ray (24) (1956 edn.), p. 138.
[dk] Ray (24) (1956 edn.), pp. 188 ff.
[dl] Ch. 25, para. 6.
[dm] "Bitter alum", lit. "gall alum", impure copper sulphate (RP 87).

is heated for a long time in an iron pan the pan is changed to copper. Thus water can be converted into copper—an extraordinary change of substance. According to the *Huang-Ti Nei Ching Su Wên*[dn] there are five elements in the sky, and five elements on the earth. The chhi[dna] of Earth, when in the sky, is moisture. Earth (we know) produces Metal and stone (as ores in the mountains), and here we see that Water can also produce Metal and stone. These instances are therefore proofs that the principles of the *Su Wên* are right."

The passage clearly shows that Shen Kua was prevented by a too uncritical acceptance of the classical five-element theory from attaining an understanding of the true nature of solution and mixture. Yet we cannot place such an + 11th-century mind in the right perspective without tracing the parallel development of thought in Europe. The observation of the precipitation of metallic copper in powdery or solid form by iron, with the formation of iron sulphate, described in the opening paragraph, was an excellent one. T. T. Read (31) tells how in our own times a process for the winning of copper from mine waters by precipitation with scrap iron was developed at Butte, Montana, in ignorance of the fact that it had been well known in Moorish Spain. Basil Valentine, in his *Currus Triumphalis Antimonii*, noted the power of iron to precipitate copper from "an acrid ley in Hungary"[do], an effect which Paracelsus still in the +16th century believed demonstrated the transmutation of metals, as also Stisser as late as +1690[dp]. Van Helmont surmised that the copper was in the solution beforehand, and Robert Boyle proved it in his *Treatise on the Mechanical Causes of Chemical Precipitation* of +1675. It would therefore be impossible to censure Shen Kua for accepting as a transmutation of elements a process which was not properly understood until six centuries after his death.

What has not generally been appreciated is how old the technique was in China. Two Han references begin the story. The *Huai Nan Wan Pi Shu*[110,dq] says that if *pai-chhing*[33] (basic copper carbonate, azurite) meets iron it turns it into copper; this may not be quite as old as Liu An, the prince of Huai Nan, himself (d. −120) but it will not be much later. The statement is repeated in the entry for copper sulphate (*shih-tan*[13]) in the *Shen Nung Pên Tshao Ching*[dr], the first of the pharmacopoeias and undoubtedly a work of the later Han

[dn] The Han medical classic.

[dna] I.e. *pneuma*; cf. Needham (21), vol. 2, p. 369.

[do] There is, of course, much doubt as to the date of "Basil Valentine". His work is more probably of the late +16th and early +17th centuries than of the +15th which was the period traditionally ascribed to it. Some earlier material was no doubt contained in it. See J. Read (30), pp. 183 ff.; von Lippmann (18), p. 640.

[dp] Roscoe & Schorlemmer (35), vol. 2, p. 413.

[dq] Cit. in *Thai-Phing Yü Lan*, the imperial encyclopaedia of +983, a great source of ancient fragments, ch. 988, p. 5*a*.

[dr] Cit. in *Thai-Phing Yü Lan*, ch. 987, p. 4*a*.

(+1st and +2nd centuries) if not of the Former Han (−2nd and −1st centuries)[ds]. Thus both these references are older than the remark of Pliny ca. +77 that iron "if smeared with vinegar or alum, becomes coppery in appearance"[dt], and also better because both distinctly specify salts of copper while Pliny's reference could be merely to the effects of rusting[du]. Knowledge of the copper precipitation effect appears again in the *Pao Phu Tzu*[dv] where Ko Hung says that if a saturated solution of copper carbonate (*tshêng-chhing*[32]) is placed in contact with iron the latter will take on a red colour like copper. Next in time comes the statement in our present text. It is interesting to note the nuance of the Chin and Liang wording which cautiously does not commit itself to an actual transmutation.

In the Sung period (+10th century onward) we begin to find evidence of the industrial use of the process. We have already read the passage in Shen Kua's book above. An interesting story in the *Lung Chhuan Lüeh Chih*[177] of Su Chhê[178] (+1039 to +1112; the brother of the famous poet Su Tung-Pho[179]) tells of his scepticism about it[dw]. As a civil official he had to deal with a merchant who came before him and said that he had a secret method of converting iron into copper by means of copper sulphate (*tan-fan*). Su Chhê said that secret methods were forbidden and if there was any value in this it ought to be disclosed to people in general, so that the public could benefit. The merchant was unwilling to do this and left, after which Su Chhê and his friends tried the effect of copper sulphate on old knives without success. This would have been about +1080. But before long the process became well known, for from about +1090 onwards, as Nakajima Satoshi has shown in a special study (20), the "wet method" (*shih shih chih lien*[180]) came into extensive use as a result of a temporary scarcity of ore for making copper cash. Copper was extracted in large-scale production both from ground water containing copper salts and from solutions obtained by leaching piles of low-grade ore. The *Sung Shih* says:[dx]

> "The method of producing 'steeped copper' (*chhin thung*[181]) is to make (lit. forge) thin plates of cast iron and immerse them in rows in troughs of blue vitriol solution (*tan shui*[182]). After some days a layer of red powder is formed by the copper sulphate over the surface of the iron; this is collected by scraping and after three purifications in the furnace gives good copper. Broadly speaking for every pound of copper 2 lb. 4 oz. of iron are needed. The Hsing-li Factory at Jao-chou and the Chhien-shan Factory at Hsin-chou produced a definite amount of this 'vitriol copper' (*tan thung*[183]) each year."

[ds] The text is accepted by Mori Tateyuki in his reconstruction, p. 24.
[dt] *Hist. Nat.* XXXIV, 149; see Bailey (1), vol. 2, p. 61.
[du] *Cf.* Bailey (1), vol. 2, p. 188.
[dv] Nei Phien, ch. 16, p. 6*a*.
[dw] Ch. 5, p. 3*a*.
[dx] Ch. 180, p. 22*a*.

This would refer to about +1100.

Under the Yuan dynasty in the +14th century the growing use of paper money led to the decline of the method and later sources indicate that it fell out of use, being known only from literary mentions. Yet it never died out, as we may infer from the reference in the *Thien Kung Khai Wu*[184] (Exploitation of the Works of Nature) in +1637, where we read:

> "If iron objects (lit. vessels) are heated and then thrown into (lit. quenched in) copper sulphate solutions, the iron acquires the colour of copper."[dy]

(*d*) The Role of Decaying Organic Matter

It is evident from the recipes given in the *San-shih-liu Shui Fa* that the intervention of bacteria cannot be overlooked, and was often positively encouraged. Even when organic matter was absent they may have been at work; thus in (5*b*) denitrifying bacteria from the earth may well have reduced the nitrate, forming ammonia and giving the blue copper ammonium carbonate. The reduction of sulphates to sulphides and polysulphides has already been mentioned (p. 140 above).

Bacteria probably played a greater role, however, in the putrefaction of the organic matter which had been added (often in considerable quantity) to the mixture. We note that of plant substances expressed juice or extract occurs four times (16, 28*b*, 30 and 32*b*) from root, wood or fruit, while expressed oil comes once (18) and plant sap twice (25 and 26). Blood was a favourite ingredient on the animal side (eight mentions, 6*a*, 11, 13, 21, 32*a*, *b*, *c*, 38), but we find beetle larvae once (32*a*) and dung once (22). It is obvious that highly colloidal solutions of partially degraded proteins would have been produced in these examples, and if the insoluble minerals such as quartz or jade (11, 13, 18, 21, 22, 25, 26, 28*b*, 32*a*, *b*, *c*) had been added very finely ground to an impalpable powder, then having regard to the charge on the particles, milky suspensions could probably have been produced. The alchemists could never have distinguished these from true solutions, and even today we should have recourse to the centrifuge to clear them.

One or two other features of the organic additions might be mentioned. Some of the saps (as in recipe 25) may have been rich in tannin, which would affect the capacity to form permanent suspensions. Again, in recipe (30) which deals with the solution of metallic silver, some suspicion is aroused by the presence of the fruits of the *mu ching* shrub. Whether or not our identification of this as a *Vitex* is right, there is no doubt that many fruits, grasses, etc., contain large amounts of cyanogenetic glucosides. On autolysis or putrefaction it is not at all impossible that enough cyanide might be freed to effect

[dy] Ch. 11, p. 5*a*. See on this the commentary of Yoshida Mitsukuni (41).

the solution of the noble metals. It may thus be significant that recipe (30) omits nitrate, though we have naturally assumed (p. 135 above) that this was not its intention.

Recipe (34) is unusual—simply the extraction of an organic material.

(*e*) Geodes and Fertility Potions

Much interest attaches to the use of conglomerate nodules or geodes (recipes 25 and 27). In the first of these, the *chiu-tzu-shih*, "the stone with nine little ones" appears to be a variety of nodule or geode with loose centres found in conglomerate rocks; at least according to Chang Hung-Chao (8), p. 270. It seems to be related to the *aetites* or "eagle-stone", an object of interest to the old European naturalists[dz]. Geodes and aetites were discussed at some length by Pliny before +77 who emphasized the belief in the value of the latter as a childbirth talisman[ea]. Here we reproduce an illustration of a geode from the *Chêng Lei Pên Tshao*[185] (Officially Revised Pharmacopoeia) of +1249; its earthy or gravelly contents can be seen escaping from the broken-open shell (Figure 1). The obvious association with fertility no doubt led to the attempts of our alchemists to get its virtue into solution.

The raw material of (27) is at first sight a difficult item. *Shih-nao* ("stone brain") is identified by Read & Pak (no. 67) as paraffin, but this can only be a loose modern usage, and has no authority from the *Pên Tshao Kang Mu* itself (The Great Pharmacopoeia of +1596) which they were abstracting. *Shih-nao yu*[186] does, it is true, mean naturally occurring petroleum and its light fractions such as paraffin and naphtha[eb] but with this we are not here concerned. Again, Read & Pak (no. 90) give *shih-nao* as a synonym of *wu-hsüeh yü-shih*[187], flaky arsenolite, but if they had read Li Shih-Chen attentively, they would have seen that this is expressly denied in his text four times[ec]. We thus isolate the proper meaning, which refers to haematitic nodules of hydrated ferrugineous geodic clay (clay ironstone), and thus makes the term more or less synonymous with *thai-i yü-liang*[188] and *yü-ai*[189].[ed] De Mély (19)[ee] though giving an erroneous character for *ai*, rightly makes the connection with the rattling geodic nodules called *aetites*. Now Li Shih-Chen significantly recounts the traditions concerning these stones. He says[ef] that they belong to the class of stalactites, by which he means that they have to some extent an organic form, being rounded

[dz] See Bromehead (7); Needham (21), vol. 3, p. 652.

[ea] *Hist. Nat.* XXXVI, 140, 149 ff. *Cf.* Bailey (1), vol. 2, pp. 123, 127, 257, 262 ff.; Bidez & Cumont (43), vol. 2, pp. 201, 346.

[eb] *Pên Tshao Kang Mu*, ch. 9, pp. 62*a* ff.

[ec] Ch. 9, pp. 61*a*, *b*; ch. 10, pp. 26*a*, *b*.

[ed] *Pên Tshao Kang Mu*, ch. 10, p. 12*a*.

[ee] Pp. 111, 225.

[ef] Ch. 9, p. 61*a*.

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Fig. 1. A geode from ferrugineous clay (from the *Chêng Lei Pên Tshao*, ch. 3, p. 91 + 1249.

"brain-like" *fossilia*, not amorphous mineral. He quotes Thao Hung-Ching[15] as say ng that they are not to be found in the ordinary formularies but only in the manuals of the immortals[eg]. The general view was that they were suitable for the preparation of elixirs of longevity and immortality; Su Kung[190] is cited with reference to an adept of the Sui period (late +6th century) Hua Kung[191], who succeeded in this method, and a number of earlier examples are mentioned. These matters are also set forth in the *Chêng Lei Pên Tshao*[111] (Officially Revised Pharmacopoeia) of +1249[eh], and in many other works of the same class. We thus have to do again with something like *aetites*, and most probably with the preoccupation of getting a fertility-promoting and longevity-promoting virtue into solution.

(*f*) Stabilized Lacquer Latex and Perpetual Youth

We now come to the curious case of lacquer. Here it is not a question of bringing something very hard and insoluble into solution but rather of preventing something liquid and creamy from rigidifying and concreting as it normally would do. Sinologists meeting in Chinese literature with statements about the harmful effects of crabs on lacquer may have thought them an old wives' tale relating to the lacquered bowls or dishes in which the shellfish were placed, but a study of the subject shows that the references are really all to the effects on the unpolymerized latex. Thus the story is more interesting chemically and more significant philosophically.

The effect of crab tissues on lacquer is a *locus communis* in ancient Chinese literature. Probably the oldest references are in the *Huai Nan Tzu*[192] book (ca. −120) which says that crabs spoil lacquer, so that it will not dry and cannot be used.[ei] Then Chang Hua[193] in his *Po Wu Chih*[194] (Record of the Investigation of Things), written about +290, says that crabs unite with lacquer forming a "medicine of the Holy Immortals" which can be taken orally.[ej] Shortly afterwards Ko Hung refers to the effect more than once. The *Pao Phu Tzu* speaks of crabs and lacquer in the following words:[ek]

> "Pure lacquer(-tree latex) prevented from becoming sticky (i.e. setting), if eaten, enables a man to associate with the immortals and attain longevity. The method of making it edible is to take ten large specimens of 'the Gutless Lordling', otherwise known as crabs, and throw them into lacquer, or else use an aqueous suspension of mica or of jade. When this potion is ingested the nine parasites will quit the body and bad blood will leave by way of the nose."

[eg] Ch. 9, p. 61*b*.
[eh] Ch. 4, pp. 115, 116.
[ei] Ch. 6, p. 4*a*, ch. 16, p. 14*b*.
[ej] Ch. 4, p. 6*a*.
[ek] Nei Phien, ch. 11, p. 12*a*, *b*.

The translation of Feifel[el] is rather unsatisfactory here. Another passage which simply refers to the effect of crabs on lacquer is quite wrongly translated by him.[em]

When one comes to the Sung there are many references. Fu Kung's[195] *Hsieh Phu*[196] (Discourse on Crustacea) quotes Thao Hung-Ching (+5th century) as saying:[en]

> "According to the recipes of the immortals crabs thrown into lacquer form an aqueous solution, which brings longevity when consumed."

The great poet Su Tung-Pho[179] refers twice to the phenomenon. In his *Wu Lei Hsiang Kan Chih*[197] (On the Mutual Responses of Things according to their Categories)[eo], ca. +1080, he says that it is the "fat" (*kao*[198]) of the crabs which is responsible; and Su Sung[199] in his *Pên Tshao Thu Ching*[200] (+1070) refers[ep] the effect to the "yellow" (*huang*[201]), which might be roe, but more probably means hepatopancreas, as in the case of Su Tung-Pho. The latter's other reference[eq] mentions the mixing of the crab material with "damp", i.e. not set, lacquer, with the result that it remains liquid. That our text refers to crabs as such may be an indication of its early date. Yet another Sung reference, from the +12th century, in Li Shih's[202] *Hsü Po Wu Chih*[203] (Continuation of the Record of the Investigation of Things)[er] simply says that "after coming in contact with crabs, lacquer will not concrete".

Since lacquer produces a well-known allergic reaction involving swelling and inflammation of the skin, etc., it is not surprising that crab tissues were appealed to as a method of therapy. In the *Pên Tshao Kang Mu*[es] Li Shih-Chen gives crab extract or brei together with several plant drugs as an antidote. Elsewhere[et] he quotes a story from a Sung source, the *I Chien Chih*[205] of Hung Mai[206] (+1123 to +1202) to the effect that a thief having been blinded with lacquer was healed by the application of crab brei.

[el] Feifel (12), p. 20.

[em] Feifel (10), p. 197. *Pao Phu Tzu* (ch. 3, pp. 8*b*, 9*a*) says: "I can guarantee that it is possible to distil mercury and to search for (the art) of making gold and silver . . . As for the transformation of lacquer by crabs and the spoiling of wine by hemp(-seed oil) . . .". Feifel writes: "I warrant that one can make people fly (with the help of) the *liu-chu* and that one can make gold and silver . . . If, however, the crab heals the lacquer-sickness, if hemp sets distilled spirits in fermentation . . .". So this begins by missing the reference to distillation and ends by a biochemical impossibility.

[en] P. 8*b*.

[eo] P. 1.

[ep] Quoted in the *Chêng Lei Pên Tshao*[185], ch. 21, p. 426.2.

[eq] In *Ko Wu Tshu Than*[204], ch. 1 p. 13.

[er] Ch. 9, p. 5*a*.

[es] Ch. 35, p. 20*a*.

[et] *Pên Tshao Kang Mu*, ch. 45, p. 24*a*.

All this is quite comprehensible if the basic facts about lacquer are recalled. After being tapped from the tree the creamy grey latex, left to itself, gradually separates into four or five layers of different properties, but if held in complete darkness in a damp atmosphere can be conserved almost without change for several years. On exposure to light, warmth and a relatively dry atmosphere, however, the latex turns first to a chocolate brown colour and eventually sets to a hard black extremely resistant substance.[eu] This material, previously impregnated with various colours and gold or silver, or afterwards carved and treated in various ways, has been the basis of China's lacquer industry for more than two thousand years[ev].

Lacquer may be said to have been the most ancient industrial plastic known to man. The chemistry of the process is of considerable interest[ew]. As much as 75 per cent. of the latex consists of one or another catechol derivative (urushiol, laccol, moreacol)[ex]; having two hydroxyl groups on a single ring and one long (e.g. C^{11}) side-chain containing at least one or two double bonds. The oxidizing and polymerizing agent is the enzyme laccase, and the process needs oxygen as well as manganese as co-enzyme. The discovery of laccase by Gabriel Bertrand in 1894 (3) was one of the great milestones in the history of enzyme chemistry.[ey] But the process becomes even more interesting when we set it in the broad framework of its biological significance. First the laccols are closely related to the active principles of the poison-oak and poison-ivy (e.g. lobinol), which also have a deleterious action on man. Secondly laccase as a catechol-oxidase is closely related to the polyphenol-oxidases which play such a prominent part, not only in the darkening of plant tissues, but also in the protein-tanning and melanin-blackening of the exo-skeleton or cuticle throughout the whole world of insects.[ez] Indeed polyphenols and their oxidases having

[eu] Set lacquer is almost untouched by strong acids and alkalies, insoluble in all the usual solvents, extremely resistant to bacterial attack, heat-stable up to 400–500°, as an electrical insulator only ten times less effective than mica—in fact, as a vegetable product altogether extraordinary.

[ev] Excellently preserved and beautifully patterned lacquer bowls, boxes and other objects not only from the Han but from the −4th century Warring States period are preserved in contemporary Chinese museums, e.g. at Chêngchow.

[ew] See the reviews of Brooks (5) and (6).

[ex] The compounds are named in accordance with the species of tree which yields them, here *Rhus vernicifera* from China and Japan, *Rhus succedanea* from Annam, and *Melanorrhoea laccifera* from Cambodia.

[ey] The most recent and complete study of it is due to Keilin & Mann (16) and (17), who have established that it is a copper-containing protein accompanied by a blue pigment which may be its prosthetic group.

[ez] See the reviews of Wigglesworth (40), Mason (42) and Dennell (9). The original discovery of the tanning was due to Pryor (23), and it was Bhagvat & Richter (4) who established the extreme richness of insects as well as plants in polyphenol oxidases.

similar functions have a still wider distribution among invertebrates. Besides there is the close parallel among the higher animals of the formation of melanin, the primary black and brown pigment, by the action of tyrosinase on tyrosine. Thus the lacquer process is only one special case, though of outstanding industrial importance, of a general pattern almost as widespread as plant and animal life itself.

What part, then, were the crab tissues playing? There can be no doubt that the ancient Chinese, before the —2nd century, had accidentally discovered a powerful laccase inhibitor. By preventing the action of the enzyme the darkening and polymerization were also prevented. So great an interference with the course of nature, analogous to the arrest of a spontaneously occurring rigidification and ageing process, must have seemed highly significant to the alchemists preoccupied by the preservation of supple youth and the postponement or elimination of ankylosis and death. Moreover this action of crustacean tissues is not unique, for recent researches have shown that they contain a powerful though somewhat enigmatic inhibitor for D-amino-acid oxidase.[fa] Even some of the alleged therapeutic effects of crab tissues might now make sense, e.g. the case of the thief if full setting had not occurred; though the action on the dermatitis was presumably imaginary since the poisoning is due to the urushiol itself and not to the laccase or the polymer. As regards the belief that powdered mica or jade would also prevent the coagulation of lacquer latex, one wonders whether perhaps crab tissue was not already added. Of course if the mineral was in the form of an impalpable powder the colloidal solution of latex would be affected by the charge on the particles and it is just possible that the laccase enzyme protein might be prevented from access to the substrate.

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6. 八公
7. 劉安
8. 淮南
9. 礬石
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11. 丹砂
12. 硝石
13. 石膽
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15. 陶弘景
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130. 鹵鹹
131. 金溜液
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158. 范子計然
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175. 沈括
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190. 蘇恭
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193. 張華
194. 博物志
195. 傅肱
196. 蟹譜
197. 物類相感志
198. 膏
199. 蘇頌
200. 本草圖經
201. 黃
202. 李石
203. 續博物志
204. 格物麤談
205. 夷堅志
206. 洪邁
207. 開寶本草
208. 馬志

THE *TURBA PHILOSOPHORUM*

A Preliminary Report on Three Cambridge MSS

By M. Plessner*

Almost 30 years have passed since J. Ruska edited the *Turba Philosophorum*.[1] The book had but little impact on contemporary research—even taking into consideration the small number of scholars interested in the history of alchemy —and the reviews do not show that any serious attention was paid to the results of his pioneering efforts. E. J. Holmyard is practically the only writer to have cited Ruska's theses other than by reference[2]; and there has never been any adequate criticism of Ruska's treatment of the text and the translation.[3]

As Ruska's former assistant at the Berlin *Forschungs-Institut fuer Geschichte der Naturwissenschaften*, which he had established, I was entrusted to review the book immediately after its publication. A first fleeting glance at the contents revealed that it would be necessary for me to undertake a very considerable amount of work before being able to make a competent criticism. This I was not in a position to do up to 1933, when I was forced to leave the University of Frankfort-on-Main. Two years later, after I had settled down in Palestine, I was able to study the book, but it took yet another two years before I finished a comprehensive review in 1937. The editor of *Der Islam*, having originally asked me for the review, felt compelled to desist from its publication after November, 1938. Following this, I proceeded to revise the whole review and to remake it into an independent paper which I sent to George Sarton for publication in *Osiris*. By then, World War II had broken out, and the British Censor returned the manuscript.

For the moment, I had to leave it at that. I presented the main results of my examinations in 1944 at the annual meeting of the Jerusalem Hebrew University *in memoriam* L. Billig, the late Lecturer in Arabic, and this paper was published in a Hebrew version[4]. In 1950, I read a paper on the advanced results of my investigations, to the 6th International Congress for the History of Science, which took place in Amsterdam. When G. Sarton came to Israel in 1953 to attend the 7th Congress in Jerusalem, he was prepared to recommend

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[1] J. Ruska: *Turba Philosophorum. Ein Beitrag zur Geschichte der Alchemie.* Berlin, 1931.

[2] *ISIS*, XX, pp. 302–305; *cf.* also his *Alchemy*. Penguin Books, 1957, p. 80 ff.

[3] G. Goldschmidt, *Deutsche Literaturzeitung*, 1933, 1478–82, extols Ruska's treatment of the text, in words which prove that he was not sufficiently versed with the problem of the textual history of the book.

[4] *Commentationes Iudaico-Hellenisticae in Memoriam Iohannis Lewy*, 1949, pp. 125–38.

the paper for publication in *ISIS*, and there it was published in the following year[5]. At that time, the main results of my investigations could be seen in the dating of the text, a statement on its presumable author, and the commentary on the nine cosmological *sermones* as an alchemical interpretation of the doctrines of nine pre-Socratic philosophers; the identity of three of them had still been open for discussion.

There were two main points which, so long as no MSS. were available, caused me a certain scientific uneasiness. My doubts were only too reasonable, particularly in regard to Ruska's estimate of the MSS. that he used; and he was certainly incorrect to have renounced the use of all the other MSS. known to, and described by, him. There is also the fact that Ruska's text of the *Turba* ends abruptly, and at the same point as the printed editions, without a proper conclusion, obviously leaving *sermo* 72 unfinished. I expressed my uneasiness in my book *Pre-Socratic Philosophy and Greek Alchemy in Arabo-Latin Tradition*, which will shortly be published, not knowing that before its publication I would have an opportunity to examine some of the manuscripts which Ruska had disregarded.

In 1954, I attended the 23rd International Congress of Orientalists at Cambridge. Of the MSS. that Ruska listed, but neglected, there are no less than three[6] in three Cambridge libraries. I took advantage of my stay at Cambridge and examined them[7]. The findings were highly surprising: all the three MSS. were found to offer the continuation of *sermo* 72 which I had believed incomplete. A number of additional *Turba*-speeches followed and, moreover, the latter were identical in all the three manuscripts. This was especially significant, since each of the three MSS. were independent of each other. It was only after I had surveyed them that I became aware of the fact that not all the MSS. used by Ruska terminate where his edited text breaks off, but that the old prints of version "A" influenced his conclusion.

At the present state of affairs, it is too early to edit the new texts: before doing this, it would be necessary to make a further examination of all the known manuscripts, without regard as to whether Ruska ever saw or used them. In that way a reliable text of the new passages could be gained. The following remarks are intended to provide a preliminary survey of the extent, the contents, and the character of the new texts.

That the printed version "A" was not arbitrarily shortened by the editor of that time, is proved by another MS. (Oxford, Corpus Christi College 125),

[5] *ISIS*, XLV, 1954, pp. 331–338.

[6] *Cf.* Ruska, *op. cit.*, pp. 80–81.

[7] I wish to record here my grateful thanks to the Librarian of St. John's, for kindly allowing me to examine the MS. entrusted to his custody, though the library was closed at that time.

which Ruska had known as well[8], and which I had also examined in 1954. This manuscript does, in fact, end at the very point where version "A" breaks off.

The three Cambridge MSS. are: 1. St. John's College, No. 182 of the printed catalogue, press-mark G.14, dated 10 December, 1479; 2. Trinity College, No. 1122 of the printed catalogue, press-mark O. 2. 18, undated, and believed by the cataloguer to be of the 14th or 15th century; 3. University Library, No. 1255 of the printed catalogue, press-mark Ff. IV.12, 13, dated 16 January, 1529.

Ruska devoted one and a half pages of his book to a discussion of the St. John's manuscript. The major part of the discussion consists of a print of the *Incipit* and the *Explicit* of the manuscript. Apparently he only used photographs of the beginning and the end of the text, and neither saw the MS. itself, nor inquired after it, but relied on the printed catalogue. However, the MS. was folioed twice, and Ruska obviously used one kind of paging for the *Incipit* and the other one for the *Explicit*. Hence he came to the conclusion that the MS. consisted of no more than 25 small folios comprising but thirteen *sermones* at the utmost, i.e. slightly more than one sixth of the whole book. The text of the *Turba*, as presented by this MS., actually fills no less than 121 folios—five times as much as Ruska had believed. And since the beginning and the end of both the other Cambridge manuscripts are identical with the beginning and the end of the one and only manuscript—MS. St. John's—that Ruska examined more closely, he concluded that the former manuscripts were just as fragmentary, and left them unexamined. The Trinity College MS. has, in fact, 19 folios in a very small script, and the University Library MS. has almost 70 folios[9].

Since the manuscripts originated in between the 14th and 16th centuries, and are considerably longer than the printed version and Ruska's edition, it becomes necessary to collate them in order to find out in what manner they offer new or better readings than Ruska's edited text. I would, however, suggest that all the MSS., whether used, or left unused by Ruska[10], should be collated, in view of the fact that, in numerous instances, Ruska's readings are disputable. In order to come to this conclusion, one has but to look up the Arabic original, or to reconstruct it where not extant. Even Ruska's reading of the text of the manuscripts, upon which he based his edition, is not fully incontestable, as can be seen from the facsimile page of MS. Berlin in his book.[11] None of the above remarks are, however, meant to depreciate Ruska's extraordinarily courageous and fertile endeavours; they merely serve to remove the

[8] Ruska, *op. cit.*, p. 75 f.

[9] As early as 1857, the author of the printed catalogue remarks: "This *Liber Turbe* corresponds very nearly with that printed by Mangetus, and with that in the *Theatrum Chemicum*, AS FAR AS THEY GO, BUT IS LONGER BY 9 CHAPTERS; and the concluding chapter in the edition "Philosophus inquit" IS SHORTER THAN IN THE PRESENT MS."

[10] *Cf.* the chapter "Die handschriftliche Ueberlieferung" in his book, pp. 69–94.

[11] For particulars, see my forthcoming study.

erroneous conception that the philological work on this text has been completed.

On the whole, there are seven or eight[12] new *Turba*-speeches which provide a total of 79 *sermones*. Whether all of them are part of the original *Turba*, is more than doubtful. *Sermo* 72 of the "Philosopher" is followed by that of Pictagoras (101v.—the numbers refer to the St. John's MS.); then comes *sermo* 74 of Arisleus (103r.), the same person who was ordered by Pythagoras to call the assembly of philosophers; Arisleus's is followed by No. 75, the *sermo* of Leucippus (107r.), and he is followed by Democrites, *sermo* 76 (114v.).

The sequence of orators with Greek names then ends. They are followed by two orators with Arabic names, i.e. No. 77, Albemazar (115r.), and No. 77a, Abebecar (116v.). I refer to the speech of Abebecar as No. 77a, because in the MSS. it does not form the beginning of a new paragraph; nor does his picture appear in the margin of St. John's, which depicts all the other orators. It is uncertain whether he is quoted by his predecessor, Albemazar, or whether he is an orator in his own right at the assembly. In any case, his sermon bears a number like those of all the other orators, and the number appears in the margin of the MS.

The last two orators are not even Arabs; number 78 is the *sermo* of Marcus Rex Grecorum (118r.), and number 79 is that of Arthurus (120r), i.e. King Arthur.

To what extent the new sermons are part and parcel of the original Arabic text of the *Turba*, is, as yet, not clear. Since the edited text contains none but classical names, Democrites is likely to have been the last of the orators whose speeches formed a part of the original Arabic version. If so, the following three or four sermons were certainly added by the Latin translator, or even after his time; however, this cannot be verified until the text is thoroughly examined with a view to the elucidation of its contents, and the style in which it is written.

The sermon of the Philosopher, after the end of the text in Ruska's edition[13], continues as follows: "Hoc scitote quod omnis lapis apparet mortuus, igne tamen factus est viscosus . . ."

It appears that the character of Pictagoras' sermon does not differ at all from that of the alchemical *Turba*-speeches. At the end, he asks Arisleus to explain his doctrines to the assembly in an easily understandable manner. Arisleus now proceeds with his sermon, which is also preserved outside the framework of the *Turba*, and is separately edited by Ruska in the last part of

[12] The author of the catalogue of the University Library, Cambridge, in mentioning 9, overlooks the fact that the speeches in the MS., from the beginning, are counted differently to Manget's and reach as far as No. 81 and that, on the other hand, the Philosopher's speech has the number 73, and not 72.

[13] p. 170.

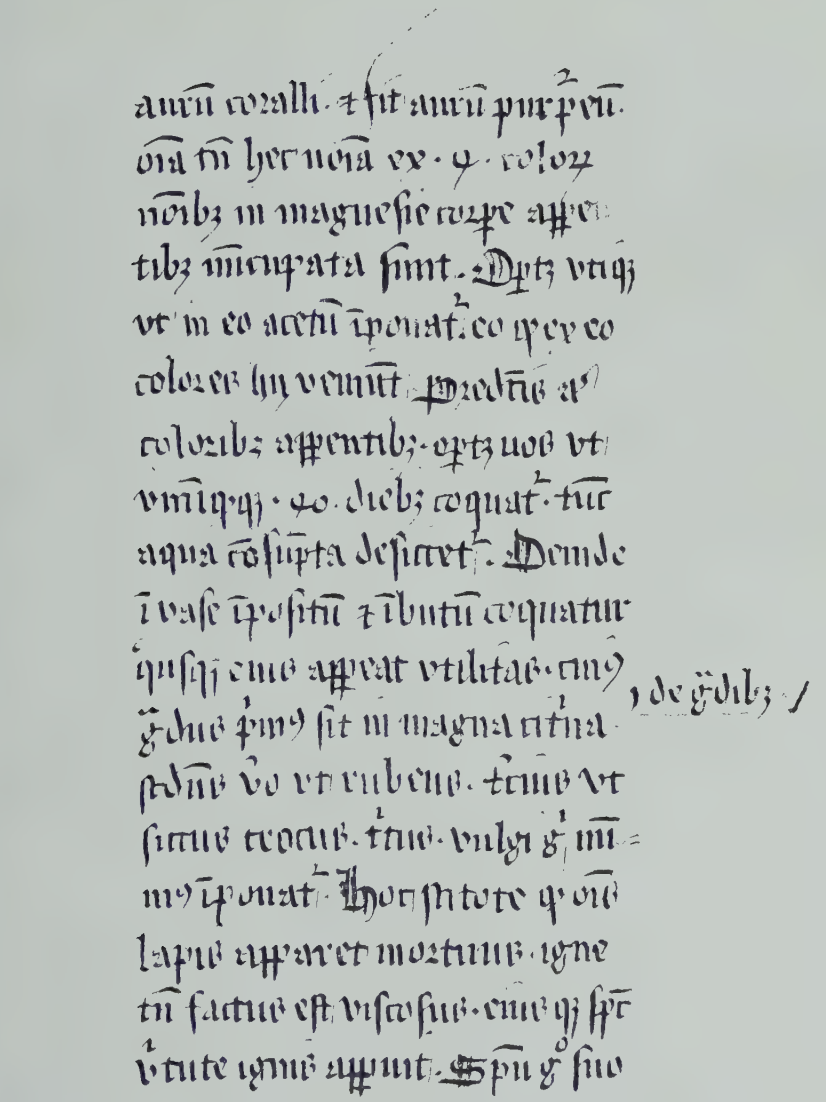

Plate I. Reproduced by courtesy of St. John's College, Cambridge, from MS. G. 14, fol. 100r.

Demetrites

Plate II. Reproduced by courtesy of St. John's College, Cambridge, from MS. G. 14, fol. iiii r.

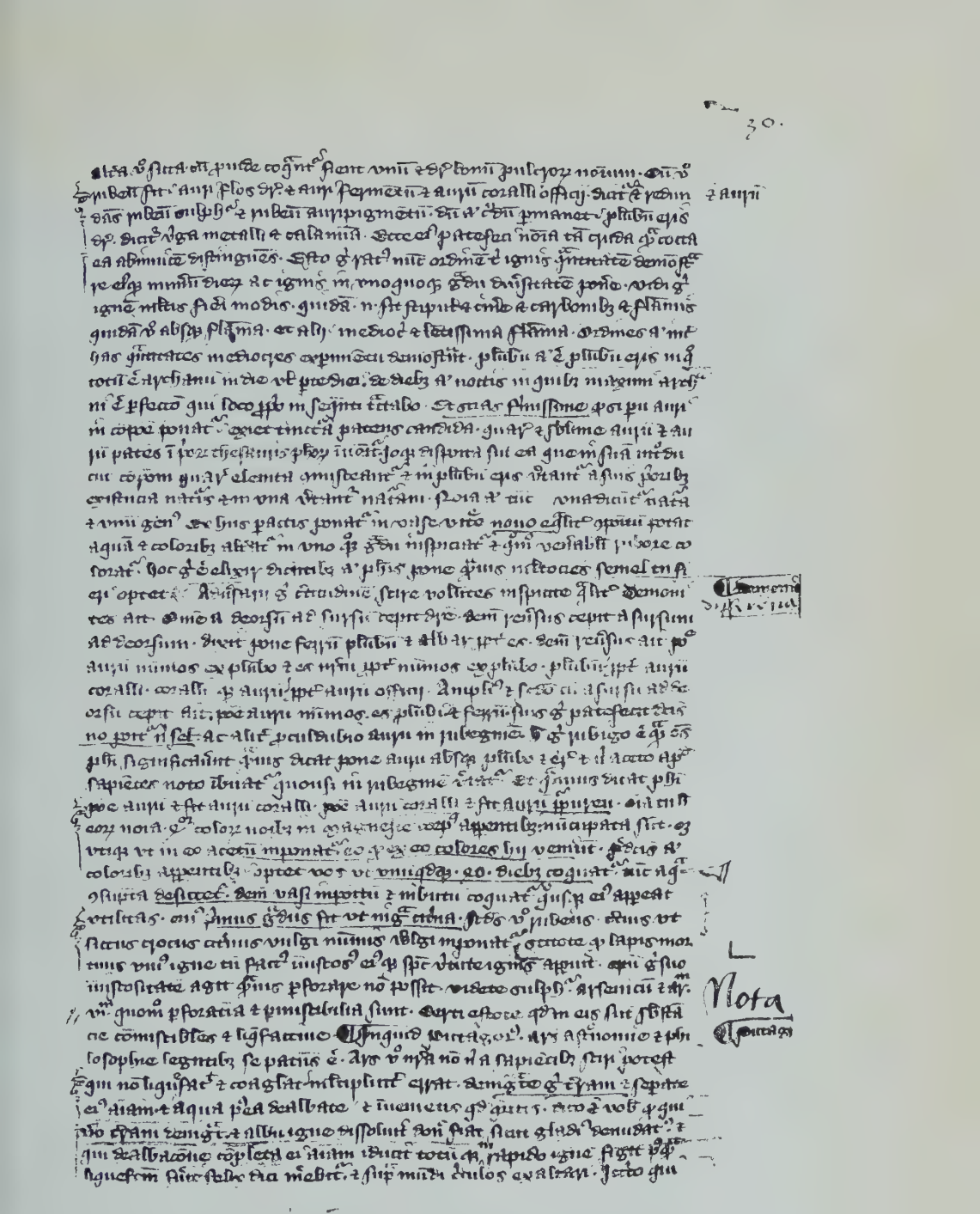

Plate III. Reproduced by courtesy of Trinity College, Cambridge, from MS. O. 2. 18, fol. 30r.

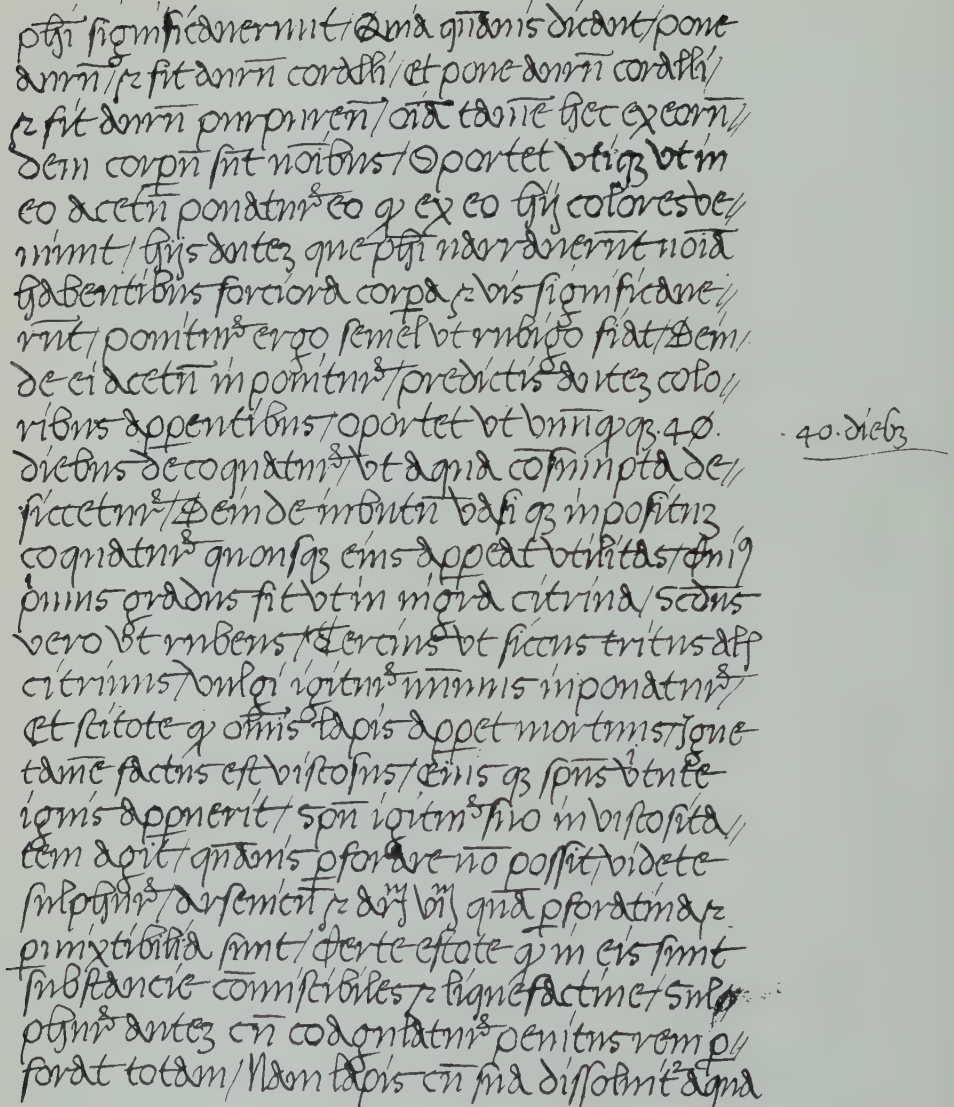

Plate IV. Reproduced by courtesy of University Library, Cambridge, from MS. Ff. iv. 12. fol. 184r.

his book[14]—he had published a German edition at an earlier date[15]. That the sermon appears in the three Cambridge MSS., not as an independent text, but within the sequence of *Turba*-speeches, gives rise to the question as to whether it forms an annex, as Ruska believed, or whether it is an integrate part of the *Turba* text, in the same manner as the *Tabula Smaragdina* was originally an integrate part of Apollonius' "Book on the Causes"[16]. It is truly remarkable that the sermon suddenly exchanges the style of a theoretical discussion for that of an autobiographical narrative—clearly discernible in Ruska's printed text and his translation. For this narrative style is continued by the succeeding orators, Leucippus and Democrites.

Special attention should be paid to Democrites' mention of *medicos egipciacos et alexandrinos* (fol. 111v.). The last three or four sermons delivered by non-Greeks drop the narrative style; they were obviously copied by the Latin author from undoubtedly genuine *Turba*-speeches.

Whom Marcus, the King of the Greeks, impersonates—provided the name is not mutilated—is a point yet to be cleared up. There has never been a Byzantine Emperor of that name; and, with the exception of Marcus Aurelius, no such ruler is indexed in William L. Langer's *Encyclopædia of World History*. Of particular interest is the fact that King Arthur, by attending an assembly of alchemists, plays a similar part to that of the Emperor Heraclius. It is left for a mediaevalist to prove to what extent King Arthur's role as an alchemist can be based on the legendary tradition of King Artus.

The conclusion of all the three MSS. is more or less the same, as Ruska had already discovered. The Trinity College and University Library MSS. differ only negligibly from the St. John's MS., in regard to the sermons' numbers. Pictures of the orators are only to be found in the St. John's MS.; facsimiles [See Plates I–IV] are added to give a proof of the script of all the three manuscripts, and of the pictures in St. John's[17].

Thanks to the munificence of the Warburg Institute in London, I am in possession of microfilms of the new *Turba*-passages, which, I am confident, will enable me to submit a readable text within a reasonable time.

[14] pp. 323–328. In two of the MSS. forming the basis of Ruska's edition, the *Visio* comes in between sermons 71 and 72. *Cf.* p. 169.

[15] *Historische Studien und Skizzen zur Natur-und Heilwissenschaft, Festgabe fuer Georg Sticker*, Berlin, 1930, p. 22 ff. (I have been unable to examine this book).

[16] J. Ruska: *Tabula Smaragdina*, 1926; Paul Kraus: Jābir Ibn Hayyān, II, Le Caire, 1942, pp. 270–303. *Cf.* also M. Plessner: *Neue Materialen zur Geschichte der Tabula Smaragdina*, in *Der Islam*, XVI, pp. 77–113.

[17] This article—which I have much pleasure in dedicating to Dr. H. E. Stapleton on the occasion of his 81st birthday—is based on a paper that I read on 26 February, 1959, to the Jerusalem Branch of the Israel Society for the History of Medicine and Science.

I wish also to express my grateful thanks to Dr. Stapleton for the kindly and helpful interest that he has always extended to me in my studies.

I am indebted to the Librarians of University Library and Trinity College, Cambridge, and to the Master and Fellows of St. John's College, Cambridge, for permission to reproduce facsimiles of the relevant MSS. depicted in this article.

THE REDISCOVERED ORIGINAL MS. "EHRENRETTUNG DER ALCHYMIE" OF THE TÜBINGEN ALCHEMIST JOHANN CONRAD CREILING (1673-1752)

By Karl Frick*

In 1730 the brothers Cotta of Tübingen published an alchemistic book of 424 pages, written anonymously, and entitled *Die Edelgeborne Jungfer Alchymia . . .*[1]: this edition was reissued in the same year but with a different title-page, by the famous publisher of alchemical books Samuel Roth-Scholtz.[2] The book soon occupied an important position in the alchemistic literature of the time; to-day both editions are scarce. Shortly after their publication, there was much speculation concerning the authorship of this anonymous work.

Ferguson[3] tells us that:

> . . . The authorship is ascribed to Creiling also in the *Fama Mystica Hermetica*, 1772, p. 22, and in the *Sammlung der neuesten . . . Begebenheiten*, 1780, in the preface. He is called the author of the very rare *Ehrenrettung*, afterwards issued with the ludicrous title *Die Edelgeborne Jungfer Alchymia.*
>
> Still more definitely is the subject discussed by Roth-Scholtz, who speaks of Creiling as his best friend and patron. He tells us that the MS. of the book was complete prior to 1727, and in that year he printed the title and contents from the MS. in his *Bibliotheca Chemica.* The book was eagerly looked for by the believers in transmutation, and in 1730 he expresses the hope that, as it deserved to be printed, the publication would not be delayed, for it would be a misfortune if the author did not

* Bochum, Westring 55.

[1] "Die Edelgeborne Jungfer Alchymia, oder: eine durch Rationes, viele Exempla und Experimenta abgehandelte Untersuchung, was von der Alchymia zu halten und vor Nutzen daraus zu schöpffen seye, nebst einem Zusatz von der Medicina Universali, Universal Process und einigen Kunst-Stücken, aus der Alchymie. Tübingen bey denen Gebrüdern Cotta, 1730."

[2] "Ehren-Rettung der Alchymie, oder Vernünfftige Untersuchung, was von der herrlichen Gabe, welche die himmlische Weifsheit denen Menschen geschencket und insgemein mit dem verächtlichen Nahmen der Alchymie beleget wird, zu halten seye. Durch Rationes, auch viele curiosa Exempla und Experimenta abgehandelt. Wobey noch von der Medicina Universali Meldung geschiehet. Sammt einem Anhang des Universal-Processes zweyer alten wahrhafften Philosophorum, und kurtzer Consignation etlicher Kunst-Stücke aus der Alchymie. Nich nur denen Liebhabern dieser edlen Wissenschaften, sondern auch allen andern, was Standes sie seyn mögen, nützlich und vergnüglich zu lessen. Ehedessen geschrieben von einem bekannten Philosopho. Nun aber auf vieler Verlangen an Tag gegeben von einem Liebhaber der Chymie. Herrenstadt, bey Samuel Rothscholtzen, MDCCXXX."

[3] J. Ferguson, *Bibliotheca Chemica*, Glasgow, 1906, vol. 1, pp. 182–183.

> live to see it finished. The title given by Roth-Scholtz is that of the *Ehrenrettung*. The publication actually took place in 1730, but it must have been after that of Roth-Scholtz's *Theatrum*, in which the above remarks occur. What produced the change of title from what stood in the MS. in 1727 I have not discovered. The alteration must have been made almost at once and the *Ehrenrettung* title must have been quickly cancelled, or the copies withdrawn from circulation, for that form is certainly far less common than *Die Edelgeborne Jungfer Alchymia*. I have seen several copies of the latter, but only one of the former: and it is seldom that both titles are quoted. Thus while Gmelin mentions only the former, Fuchs, Schmieder, and Kopp seem to know the latter alone . . .

Johann Conrad Creiling was born at Löchgau (Württemberg), where his father was a clergyman, on 9 July, 1673. A few biographical details are to be found in the sources listed by Ferguson[4]. From 1701–1745 he was Professor of Mathematics and Physics at Tübingen; ever devoted to alchemy, he experimented in his laboratory and, up to the time of his death, he firmly believed in the *Lapis Philosophorum*. He died at Tübingen on 14 September, 1752.

Through a fortunate discovery in the archives of the town of Bochum, the present writer has succeeded in rediscovering the manuscript mentioned above by Roth-Scholtz and Ferguson, and is therefore enabled to throw further light on the question of Creiling's authorship[5].

No less a person than Dr. Carl Arnold Kortum (1745–1824), not unknown in the literary field, and *Jobsiade* poet, physician, and alchemist, had been engaged in a study of Creiling and his alchemistic writings; moreover, in addition to Kortum's own papers preserved in the town archives at Bochum, there is also a manuscript:

> D. C. A. Kortum/Wichtige Nachricht/Von Creilings Philosophischen Testament und dem darin räthselhaft beschriebenen alchimistischen Partikulare; genannt Aqua benedicta oder Aqua gratia./Worin zugleich die Auflösung des gedachten Räthsels mitgeteilt wird./ 1822 im Januaris geschrieben.

Apart from this manuscript, there is also a far more valuable one in the Bochum archives; it is Creiling's original MS. of his work entitled *Die Edelgeborne Jungfer Alchymia*. Kortum gives us important information about her fate in his preface to Creiling's manuscript:—

> Der berühmte J. C. Creiling, Professor in Tübingen, welcher als ein groβer Chimist und Adept bekannt geworden, hat vormals ein Buch herausgegeben unter dem Titel: Die Hochedelgeborne Jungfer Alchimie,

[4] *Ibid.*, p. 183. See also Ferchl, *Chemisch-Pharmazeutisches Bio-und Bibliographikon*, 1937, p. 108.

[5] I am indebted to the Municipality of Bochum and to their Archivist, Dr. Croon, for kindly allowing me the use of the Archives.

welches unter dem Titel: Ehrenrettung der Alchymie nachgedruckt worden. Dieses Buch sowohl als auch der Nachdruck sind schon sehr selten mehr in den Buchläden anzutreffen.

Im Jahr 1784 wurde mir von der Schwiegertochter des gedachten Creilings ein Manuscript verehrt, welches dieser Creiling eigenhändig geschrieben hatte. Dieses Manuscript war das ächte Concept zu eben obgedachten Buche. Es war aber hin und wieder sehr defect, so daß nicht allein ganze Bogen daran fehlten, sondern auch viele einzelne Stellen unvolständig waren. Ich habe das fehlende alles ersezt und aus eben gedruckten Buche: Ehrenrettung der Alchymie, getreulich nachgeschrieben, so daß es jezt volständig und gehörig geordnet ist.

Die Rarität dieses Manuscripts leuchtet also von selbst ein. Man wird meine Handschrift leicht von der wahrhaftigen eigenen Handschrift des berühmten Creilings unterscheiden können. Zu mehrerer Nachricht hierin derart, daß der erste Bogen der Vorrede, so wie auch der größte Teil des ganzen Buches unter der wahrhaften Hand des authoris hier sich befindet.

After Kortum's preface, there follows on the second page the actual title of the manuscript, viz., "Ehrenrettung der Alchymie . . ." (see note 2). This MS. contains 179 pages and was apparently bound by Kortum in contemporary boards. Of the 72 chapters, some of the dividing paragraphs are incomplete, since some of them, written in an unknown hand, have been cut out; but otherwise the manuscript is well-preserved. Together with this MS. there is the other MS. mentioned above, viz: "Von Creilings Philosophischen Testament"; and here Kortum gives us a few biographical memoranda headed "Von der Person des Creilings", of which we give below the following translation from the original German:—

["Johann Conrad Creiling was born on 9 July, 1673, in Löchgau. His father was a clergyman there, and subsequently in Ettingen. From his early childhood he had an extraordinary love of science and such a capacity for it, that he was admired by all.

A detailed account of his life which I obtained from the printed academic Programmes of his funeral, and from hand-written testimonials, and also from the verbal accounts of his relatives, I have already published in the year 1806, together with information regarding Creiling's philosophical oil of antimony, in the 7th part of the first volume of the periodical *Hermes*[6]. Creiling died on 14 September, 1752, in his 80th year. From those biographical details, and also from the writings that he left to us. it can be seen that he was an extraordinarily learned man and explored almost all branches of knowledge. His favourite subject was especially Higher Chemistry ("die Höhere Chimie"). For his

[6] *Hermes, eine Zeitschrift in zwanglosen Heften zur endlichen Beruhigung für Zweifler und Sucher*, Karlsruhe, 1805. Only two issues appeared. It was published by Baron L. Fr. von Sternhain. (cf. Kopp, Die Alchemie, 1886, vol. 12, p. 161).

alchemical experiments he had his own laboratory and several assistants, and he kept a regular diary of his work almost up to the day of his death. I have in my possession a copy of this handwritten diary with the title "Acta Laboratorii J. C. Creilingii von 1737 bis 1751".[7] There is much of interest in this diary. He left many manuscripts dealing with higher chemistry which have been entrusted to me by his daughter-in-law for copying and revision. For the most part, however, they contain nothing of importance, but are only copies of manuscripts entrusted to him by other alchemists, or extracts from many chemical books.

Of all his manuscripts, one is especially noteworthy; it bears the title *Superveniens*. I have been assured that he kept this manuscript very secret, and always carried it around with him in a special pocket; after his death it was inherited by his only son, and he too preserved it very carefully. It contains for the most part particular processes which appear to me to be rather uncertain, but also, to some extent, important.

Whether one regards Creiling as a true adept, as one does in Tübingen where he lived, and indeed in the whole of Würtemberg, (indeed some authors, e.g. Fictuld, put him in this class), at any rate I have been unable to discover from the manuscripts left by him whether he possessed the famed Philosophers' Stone. However, it is certain that he had much knowledge and experience of the art of enobling metals, and he was at least 'ein Partikularalchimist'."]

Following after Kortum's notes on Creiling, there is the actual MS. of the "Philosophische Testament".[8]

We have therefore been able to prove the supposition that Creiling was, in fact, the author of the anonymously published *Ehrenrettung der Alchymie*. Apart from the 'Ehrenrettung', there appeared in 1737 yet another alchemistic book written by Creiling, viz: "Dissertatio Academica de Aureo Vellere . . ." in three sections; a fourth section was published in 1739, and a German translation in 1787[9].

[7] This copy has apparently been lost, since it is not in the Bochum archives.

[8] Cf. a forthcoming paper in Sudhoff's *Archiv*: Frick, *Die alchimistischen Studien des Bochumer Arztes und Jobsiade-Dichters Dr. Carl Arnold Kortum* (1745–1824).

[9] The full titles of these editions are given in Ferguson, *op. cit.*, p. 183

REVIEWS

A History of Science. Hellenistic Science and Culture in the last three centuries B.C. By GEORGE SARTON. Pp. xxvi + 554. Harvard University Press: Oxford University Press. 1959. Price 63s.

The second volume of the late Professor George Sarton's history of science, most regrettably posthumous and the last one that we shall have from him of an intended series of eight volumes on a subject that he had made particularly his own, covers the last three centuries B.C. and deals with the diffusion of Greek science and culture through the Hellenistic world from the deaths of Alexander the Great and Aristotle to the birth of Christ.

The Preface indicates the author's profound appreciation of these great centuries: "It was a period of renaissance out of the ashes of pure Hellenism. During the first of those three centuries the main centre was Alexandria; during the last two the leadership was shared by Alexandria with Pergamon, Rhodos, Antioch, and other Greek cities, and more and more as the years went by with Rome. The Hellenistic world was international to a degree, polyglot and inspired by many religious faiths. The outstanding language was Greek, but the importance of Latin increased gradually with the success of Roman arms. Under Greek tutelage a fantastic mixture was allowed to brew, involving in the first place, Hellenic and Roman materials, but also Egyptian, Jewish, Persian, Syrian, Anatolian ingredients, and dashes of many other kinds—Asiatic, Indian, African. During those three centuries, geometry, astronomy, anatomy, and grammar were established for ever; technology and medicine blossomed out. The creative work might be done in many places of Western Asia, Northern Africa, or Europe, but the leaven was always Greek."

The first part, in fourteen chapters, opens with the Alexandrian renaissance and the foundation of the Museum, and proceeds to describe the work of Euclid, of Aristarchos and of Archimedes, with accounts of the advances in geography, physics and technology, and in anatomy and in medicine, with a very interesting chapter on the library of Alexandria and others on philosophy, religion, history, language, arts, letters and orientalism during the first of the three centuries in the period studied. The second part, in fourteen chapters with a brief conclusion, is concerned with the last two centuries B.C. and discusses the social background of the Hellenistic world, the religion and philosophy of that age, its mathematics and astronomy, physics and technology, natural history, medicine, geography, historiography, literature, philology, art and orientalism.

The conclusion briefly summarizes the scientific accomplishments of these three centuries of the Hellenistic age: research was organized in the Museum at Alexandria as it had never been organized before; the libraries of Alexandria, of Pergamon and later of Rome, were established; the leading philosophic school was the Stoic; the New Academy flourished; the teachings from the Garden of Epicuros were defended by Lucretius; the tradition of the Lyceum was continued; the first scientific edition of Aristotle and Theophrastos was prepared; mathematics saw a golden age that it did not see again until the 17th century; and there were advances in every field of scientific inquiry.

The volume is well illustrated, documented and indexed. It would be impertinent to make any comments on the place of any of George Sarton's writings in the literature of the history of science. While all those devoted readers of the works of this great scholar will be saddened by the thought that this is the last work which will reach us from his study, it is interesting to note that plans are being made for the completion by other hands of this valuable series.

D. McK.

Paracelsus: An Introduction to Philosophical Medicine in the Era of the Renaissance. By WALTER PAGEL. Pp. xii + 368, with 36 illustrations (including a number of Plates). Basel/New York, S. Karger AG., 1958. Price £5 18s.

In this study of 16th century philosophical medicine, Dr. Walter Pagel has given us a penetrating analysis that discloses many aspects of the basic problem which, as he says, confronts the modern historian of science, viz: "of specifying the manner in which mystical, magical and scientific elements are all blended together in a single doctrine". Dr. Pagel stresses that in presenting the 'hard' facts of scientific and medical discovery against the background of the philosophies with which they were intimately associated, "it is necessary to understand that in former times no specialization prevented the savant from blending science and medicine with philosophy, religion and cosmology . . . (for) . . . what seems to be contradiction and inconsistency to the modern mind was not necessarily incomprehensible four hundred years ago". The author's ability to enter into the spirit of the era of which he writes, is notably exemplified throughout the whole of his ensuing text. The subject matter is divided into three main parts, e.g. (*a*) Paracelsus' life and philosophy, (*b*) Paracelsian medicine, and (*c*) Sources, (ancient—mediæval—contemporary); and finally, the character and general attributes of Paracelsus is assessed, together with a summary of the arguments of his antagonists.

In his account (45 pages) of Paracelsus' life, Dr. Pagel points out that the voluminous number of extant books and papers on this subject is out of proportion to the scarcity of well-documented facts. We are given the opinion that the appellation 'Paracelsus' was a nickname bestowed on him at a later period of his life: "that he used it himself at any time cannot be demonstrated". This departs from the usual supposition that, as the late E. J. Holmyard expressed it, the name was self-bestowed to indicate that in his own opinion he was greater than Celsus. Even the year of his birth (generally given as 1493) is uncertain. This scholarly biography is supplemented with four pages of bibliographical notes, and themes such as those depicting Paracelsus as a representative figure of the Renaissance, and his attitude towards Humanism, are discussed. "At first sight", Dr. Pagel states, "*Humanism* seems incompatible with Paracelsus' attitude towards the ancients. Yet he is unthinkable without the Hellenistic blending of Jewish, Christian, Greek and Oriental ideas and symbolism as expressed in Neo-Platonism, Gnosticism and Kabbala, Alchemy, Astrology and Magic . . . moreover the humanistic reversion to classical models was associated with a quest for truth and reality, as against the fictitious—'sophistic'—embellishments added by the Arabs". In a later chapter of this book it is shown that there are demonstrable contacts and

parallels in the work of Paracelsus, with such Platonists as Cusanus and Ficinus followed by Picus, Reuchlin, Stapulensis, Bovillus, Trithemius and Agrippa.

The dissertation on 'The Philosophy of Paracelsus' occupies 76 pages. It includes a survey of Paracelsus' consequential view of cosmology, theology, natural philosophy and medicine in the light of analogies and correspondences between macrocosm and microcosm; his doctrine of 'signatures'; his censure of Aristotle and Avicenna; the role of Stars, Astrology and 'Astrosophy'; his conception of Time; the *Tria Prima*, the *Archeus*, the *Vulcan*, the *Iliaster*, the *Quinta Essentia*. We have here an exposition of Paracelsian doctrines and terminology which is treated vividly and with profound insight.

The second part, 'Medicine', is, to quote Dr. Pagel, "the core of the book", because it has been the author's main objective to explain the medical ideas of Paracelsus in the light of his general philosophy and their influence in medical history. This critical conspectus (77 pages) of Paracelsus' medical ideas and theories, ranges in extent from a discussion of his controversial cures—which were frequently regarded as bordering on the miraculous—to a brief survey of the progressive aspects of his work in various branches of medicine; and Dr. Pagel shows that "it is in his (Paracelsus') ideas on the plague that we find *actual contacts* in the *medical teaching* of . . . Marsilio Ficino (1433-99) and Paracelsus". Among the wealth of material in this section, there is an account of mediæval uroscopy and of its replacement by semi-quantitative methods—"a kind of chemical examination".

The third and final section (141 pages) of the book under review includes noteworthy chapters on Gnosticism, the Cabala, Neo-Platonism, Mediæval Pantheism; on Lullus and Arnaldus: it is concluded that there is no direct evidence of the Lullian art in the work of Paracelsus, and that a possible evidence of Lullian ideas should not, therefore, be overated. In the chapter on "Paracelsus and Alchemy", the ideas of Paracelsus are compared with the general principles of mediæval alchemy as outlined in the *Pretiosa Margarita Novella*. In a later chapter dealing with Paracelsus' achievement in pure and medical chemistry, his *Archidoxis* is regarded as having "presented for the first time a kind of system of chemistry. His chemical doctrine embraces all the chemical substances known to him and evolves a classification of operations and materials. In this he precedes Andreas Libavius". It is interesting to note that Paracelsus' "analeptic spirit of vitriol" has been recognized "as the forerunner of the 'sweet oil of vitriol' prepared by Valerius Cordus in 1540".

A general Index of eighteen pages enhances the usefulness of this important and beautifully produced book as an authoritative work of reference. It is dedicated to Dr. Charles Singer. D. G.

PUBLICATIONS RECEIVED

Revue d'Histoire des Sciences et de leurs Applications. Tome XII, Nos. 1 & 2, January-March & April-June, 1959. Paris: Presses Universitaires de France. (Annual Subscription to Great Britain and the Commonwealth, 24s.)

No. 1 contains the following articles: André Robinet: "La vocation académicienne de Malebranche". Viggo Brun: "Caspar Wessel et l'introduction géométrique des nombres complexes". Arthur Birembaut: "Les deux déterminations de l'unité de masse du système métrique".

No. 2 contains the following articles: André Nadal: "Gaston Milhaud (1858-1918)". Jean Torlais: "L'Académie de La Rochelle et la diffusion des Sciences au xviii^{e} siècle". René Taton: "Condorcet et Sylvestre-François Lacroix (1)". T. Kahan: "Sur les origines de la théorie de la relativité restreinte".

Avicenna. His Life and Works. By Soheil M. Afnan. London, Allen & Unwin, 1958.

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